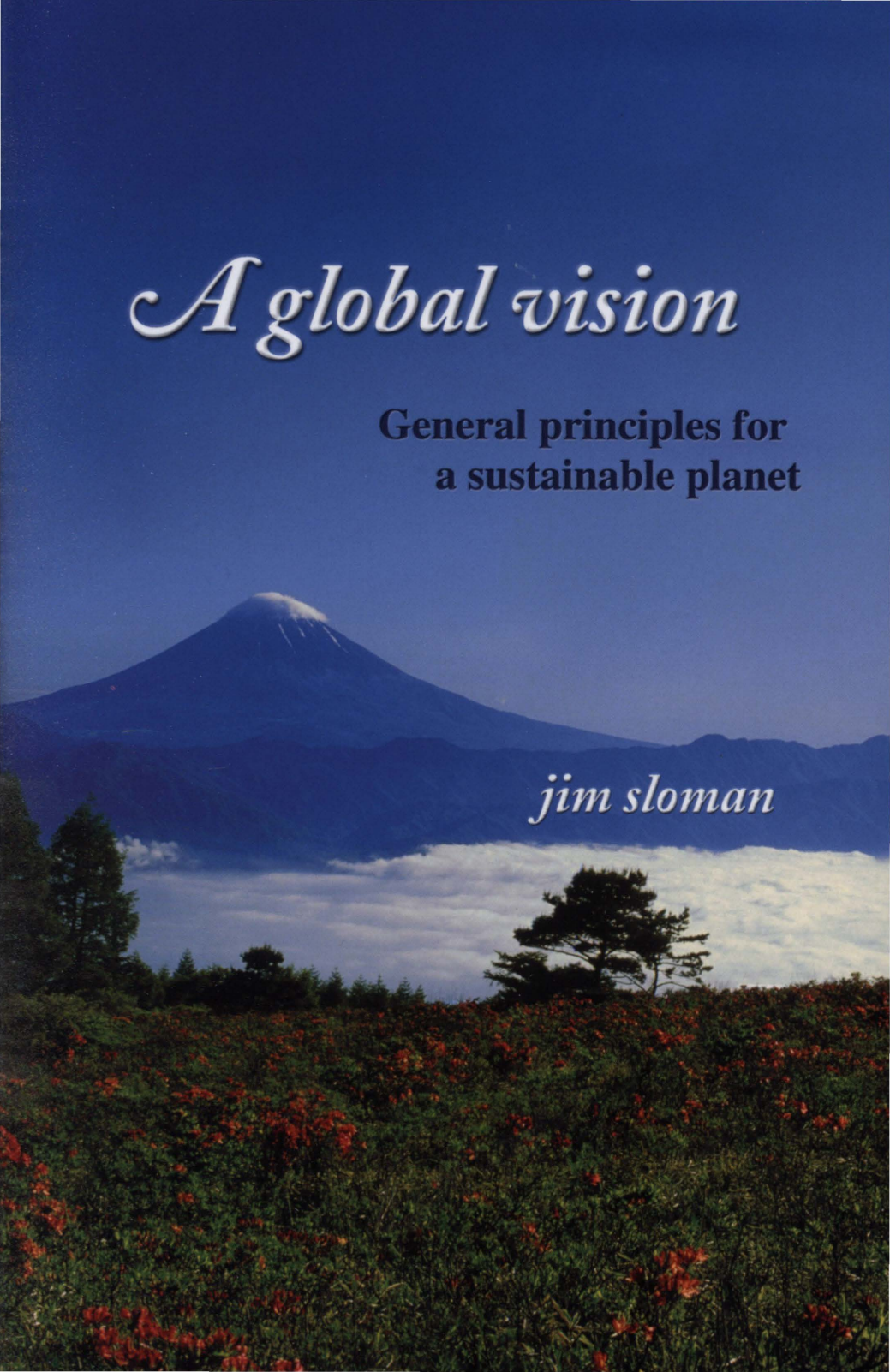
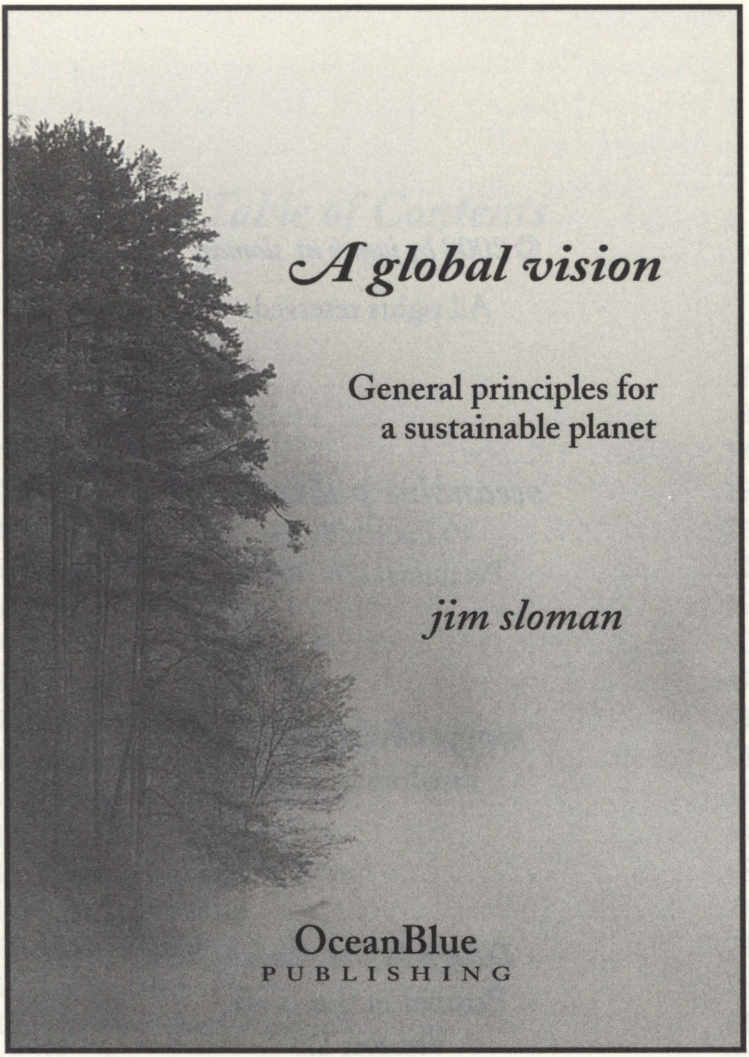
A global vision

General principles for a sustainable planet



jim sloman

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General principles for
a sustainable planet
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INTRODUCTION

There may be no sirens, flashing lights or shouts of "code blue." But the reality is that our human experience, and the larger planet it depends on, is facing an unprecedented challenge. This challenge is not just ecological, but also financial, political and connected to energy. It's all related. Unless we take some steps now to change the course we're on, life as we know it on planet earth, and in particular our human reality, could dramatically decline or even possibly cease to exist.

Many fine proposals have been offered for specific actions to be taken in various areas to deal with this or that crisis. But here our emphasis is somewhat different. Here we'll ask: *What are the general principles involved if we humans are truly going to create a sustainable planet?* In other words, we'll ask: Are there some *general principles* that could help guide us in this uncharted territory?

In order to address that question, we'll first take a look at the current situation of the world in a number of contexts including finance, geopolitics, energy and the environment. Though these dimensions and others are interconnected, to gain clarity we'll first look at them in some isolation before seeing, as the series progresses, how they might combine into a set of general principles.

We'll also take a fascinating journey into some past and present societies that either succeeded or failed—and in either case, ask why. Then, we'll follow some amazing and valuable computer research that is concerned with scientifically modeling the earth's biosphere—and see what that might reveal about our planet.

So we begin by first looking at the current situation of the world in different dimensions. And although the picture may appear grim at first blush, the picture will take on a more and more hopeful tone as we make our way through, reflecting the reality that there are solutions and it's not too late to implement them.

Finally, as this series progresses it will look more and more at an overall vision, *a global vision.*

What would a global vision of our collective future on a sustainable planet look like?

That is our overall question and objective.

Here we go . . .



1. FINANCE & ECONOMICS I

An ocean of liquidity has been sloshing over the globe as the world's central banks increased their money supplies at faster and faster rates. And those monetary increases have percolated through the world's economies, multiplying many times through the capacity of various types of financial entities to create new credit. Equally important has been the voracious appetite of consumers, corporations and governments to take on new debt.

This exponential mountain of money and credit is the defining characteristic, in the financial area, of our global situation right now. As important as other considerations might be, this is the overriding one in the financial world since it is setting the stage for radical changes in global financial and economic well-being.

Skeptical that money has been increasing at a fast rate? Here are a number of examples of the actual rates

of money increase for various countries over the last year: China, 20%; India, 24%; Australia, 14%; Mexico, 12%; Brazil, 12%; the United Kingdom, 14%; the Eurozone, 14%; the U.S. (reconstructed M3), 13%. Inflation of the money supply has been occurring all over the world.

By the way, the U.S. Federal Reserve has stopped publishing the M3 figure (the broadest measure of the money supply), so this M3 figure is the number arrived at by John Williams of Shadow Government Statistics. Now, why would the Fed want to hide the M3 number? Gee, could it possibly be because it wants to increase the money supply beyond all previous bounds without the public catching on? Yes!

What's interesting about this financial phenomenon is that so much of it takes place beneath the surface. For instance, the Fed likes to portray itself as "fighting inflation"—while, as noted, it has been facilitating an increase in the money supply at an unprecedented rate. But the story doesn't end there. This "core" increase in the supply of money is then leveraged—"geared up," as the British say—by a veritable army of banks, investment banks, GSEs, mortgage securitizers and other financial entities, all with the power to create new credit and thus more money.

Why have central banks all over the world been increasing their money supplies at an increasing rate?

It goes back to the mountain of debt mentioned

above. This huge amount of debt has created an historic degree of *leverage* throughout the system, and this vast leverage has made the global financial system much more fragile, that is, vulnerable to a crash. To prevent such a crash, central banks have been injecting more and more fiat money into the financial system to stimulate it, and the system has responded by creating mountains of new credit. It's a lot like giving a heroin addict yet another injection to prevent him/her from "crashing."

As an example of leverage, the financial analyst Ed McCarthy points out that Goldman Sachs, "the smartest investment bank in the world," has a "gearing" on its capital of approximately 32 times. *Thirty-two times.* That is eye-popping leverage, but Goldman is hardly alone in that. The mortgage GSEs Fannie Mae and Freddie Mac have some $4.5 trillion on their combined balance sheet, backed by a $60 billion capital base—*75 to 1* leverage.

Those are just two examples out of many that could be cited. High leverage has become commonplace in the financial industry. An industry which is now responsible for 40% of the earnings of the companies in the S&P 500 index, up from just 15% a few ago. Brave new world.

Why is leverage so dangerous? Let's say that we're a hedge fund and we're using 10 to 1 leverage, that is, we're borrowing $9 for every $1 of equity that we have, so we're investing $10 instead of $1. Now that's great if our investment, say into a bunch of sub-prime mortgage

CDOs, goes up. For example, if our investment goes up 10% we've doubled our money. On the other hand, *if our investment declines 10% our investment is wiped out.*

Can't happen? It just did. Two big hedge funds at Bear Stearns just went out of business, their combined equity of some $1.6 billion completely wiped out, since some of the subprime mortgage market bonds that they held went down more than 10%.

This same phenomenon has now affected funds in California, New York, Florida, Canada and Australia, as well as banks in France and Germany, and not least, investment banks in the U.S. Stay tuned.

This situation will almost certainly spread further, and given the degree of financial leverage in the system, could easily cascade into a financial crisis.

It's worth noting here that banks are regulated, but the gigantic and greatly leveraged world of hedge funds, private equity funds and investment banks are not. They can pretty much do as they please, and what they've been doing is taking on trillions in new leverage to generate higher returns. But they're not alone.

This historic credit/debt bubble—two sides of the same coin—has been expanding in all areas of the economy from corporations to governments to consumers.

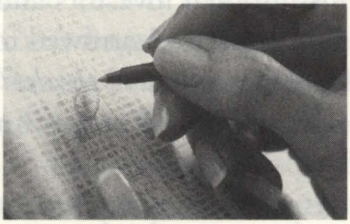
Corporations have taken on a massive amount of new debt in recent years. For example, there have been trillions of dollars in takeover activity as hedge funds and

private equity funds buy various public companies and take them private. In order to do this, these funds borrow the money from various institutional investors and then use it to finance the buy-out deal. This borrowed money, once the deal is completed, is then *added to the debt of the acquired company,* so the take-over more or less finances itself. How cool is that?

Of course, now the acquired company has a ton of new debt on its balance sheet, making it much more fragile financially than it was before, since it is operating now with much greater *leverage.* This has been happening all over, a frenzy of take-over activity, and in its wake, a growing colossus of financial overleverage.

And the vast amounts of debt taken on by acquired corporations is the least of it. Any public company that doesn't want to be taken over is also buying back its own stock (making it more expensive) and paying for it with lots of debt (making its balance sheet unattractive)—thus hoping to present itself as undesirable for a takeover.

Note that the common denominator, for both for acquired and unacquired companies, is lots of new debt. Of course, all this buying of stock has driven world stock markets—until quite recently—higher and higher in a levitating feat quite oblivious to the exponentially rising risks in the financial system.



This process has not been limited to the corporate sector by any means. Governments, led by the U.S., have also been taking on lots of new debt to pay for unfunded expenses. Funding its expensive wars in Iraq and elsewhere is costing the U.S. a bundle, about half a trillion dollars so far. Meanwhile, U.S. government spending has increased 60% just since the year 2000. In general the U.S. government is spending way beyond its means. The U.S. is not alone in that, of course, but it is the most extreme case among developed countries.

If we measure the true U.S. federal deficit by the amount of net new debt instruments the U.S. is issuing each year, then the true federal deficit is about $800 billion a year, several times the reported figure. And that's not counting our trade deficit, another $800 billion. It's also not counting unfunded obligations, which add some

$4 trillion (with a "t") every year. Unfunded obligations have increased from $20 trillion to almost $44 trillion in the last seven years. And mostly, the public has been blissfully unaware of this.

Then there's the consumer, who has added trillions in new debt in the last few years to finance an orgy of asset buying. The percentage of subprime mortgages in the U.S. rose from 5% in 2001 to 20% in 2006, a 4-fold increase in five years. Defaults in this area are now close to 13%. Even in the "normal" mortgage area, defaults have doubled in the past year. That is, if by "normal" we mean 100% financing, interest-only, no-documentation, adjustable-rate, low front-loaded teaser rates and other innovations of recent times.

Corporations, governments and consumers have all been borrowing like mad hatters. Adding to the melee are the hedge funds and private equity pools that, as noted above, have often been operating with leverage by borrowing $2 to $20 for each $1 of their own funds. And let's not forget junk bonds, emerging-market bonds, and not least, the "collateralized debt obligations" that have fueled the gigantic mortgage market since 2002. In the last 5 years, the global investment banking community alone is estimated to have added *$30 trillion* of debt.

Then there are *derivatives* (financial instruments which are dependent on other financial instruments). Some $72 trillion (with a "t") have been added just in the

last six months—more than the total just five years ago. There is an estimated current total of some $415 trillion (with a "t") in global derivatives, approximately *8 times* total global economic output. And 91% of it is over-the-counter, away from public scrutiny.

The current degree of global leverage is completely unprecedented. The mind boggles. How to describe such a network of vast leverage all through the global system? Should we call it the Mother of all Credit Cycles? The Alice-in-Wonderland Global Credit Bubble? Personally, I like Ed McCarthy's invocation of Dante. In attempting to describe the current situation, "Abandon all hope, ye who enter here."

This bubble-blowing is the same phenomenon that happened in the U.S. Confederation in the 1780s, France in the 1790s, Germany after World War I, the U.S. and Europe in the 1920s and so on—all of which resulted in either hyperinflations or depressions. The only difference is that now this phenomenon of rampant money and credit creation has been occurring on a global scale, something which has never happened before.

As noted, monetary liquidity has been flooding the world, reflected in rising stock markets and GDP all over—Brazil, China, India, Russia, Europe, the Middle East, Africa—everywhere. All the central banks and all of the various credit-creating and credit-using entities in the financial world have been participating. Profits rising

to the sky. More and more money/credit created.

And the game can't stop, because if it does the whole credit/debt pyramid will come crashing down, just like the withdrawal from any other kind of addiction.

Like a heroin addict, the injections of money and credit must keep increasing over time to get the same effect, which ensures that this process of money/credit creation must keep climbing higher and higher until the colossal debt bubble finally collapses of its own weight.

Until the process ends, welcome to more and more inflation. Here are some recent examples more or less at random: Gasoline in the U.S. is up roughly 150% in five years. Bread prices are up 15% in the last year. The price of a bee colony has increased from $55 to $135 in two years. The price of a ticket on the major discount airline has risen 29% in the last year. The newsstand price of the *New York Times* just went up 25%.

These events and others are supposedly unrelated. But they are very related. We have been living in the middle of a rising inflation, much greater than most of the public believes. As the analyst John Williams has demonstrated, if the U.S. CPI were computed today using pre-Reagan methodology it would be almost 11% a year. The official CPI released by the government, in contrast, has been hovering about 2-3% in recent years. That figure has been politically manipulated to make inflation look irrelevant.

At 11% inflation, the more accurate figure, the value of a dollar halves in 6 1/2 years. And this inflationary phenomenon has not been confined to the U.S. It has been a worldwide phenomenon directly related to the root cause of inflation—increasing amounts of fiat money and credit. (What does "fiat" mean? It means that the value of the money is not tied to anything—gold or anything else. It means it can be "created at will.")

Given this gigantic bubble of debt and leverage, it is inevitable that from time to time there will be financial panics, such as the one now occurring in the subprime mortgage market. If such a panic spreads and grows large enough, of course, it could bring about the gigantic crash to which the system has become prone. To prevent that, which has become unthinkable to policy makers, more and more money has been and will be injected into the system, ongoingly.

That's what has been happening. And it has been slowly—though at an increasing pace—destroying the value of money. As more and more dollars, yen, pounds, euros, yuans and so on are created, the value of each unit goes down. In fact, every currency in the world has been losing value in relation to gold, the historical standard of value. When we see prices increasingly rising around us, what we're really seeing is the ongoing destruction of a currency's purchasing power.



3. FINANCE & ECONOMICS III

However, there's another side to this rising money and credit creation. The vast and increasing amounts of debt that keep the system going also make it more and more fragile and susceptible to an implosion—literally, a bursting bubble. If the flow of liquidity begins to dry up, if parts of the system begin to decline or freeze up, as is now happening in the U.S. subprime mortgage markets and the U.S. buy-out credit markets, the potential is that such a cardiac event could rapidly spread to other areas of the financial system, since all of it is so leveraged.

In other words, with this epic amount of leverage everywhere, the danger is that a contagion of margin calls, debt defaults, distress selling and so on could build on itself, cascading down in a vast financial implosion as everyone sells things to lower their leverage.

The massive risk of this kind of leverage existing all

throughout the financial system is supposedly okay since it is watched over by the latest risk-management programs designed by a horde of mathematical "quants" with Ph.Ds. Of course, the same thing was said about the brilliant "quants" at Long Term Capital Management just before their huge bets failed in 1998 and almost took down the financial system with them.

In this universe, as far as I can tell, all extremes contain the seeds of their own destruction. The financial world is no different.

For example, it now takes an average of $4 of new debt to create $1 of new economic activity. To put it mildly, that is an unsustainable economic model. The financial system has gone into such a degree of overshoot that it will have to go into undershoot, at least for awhile, in order to rectify the maladjustments and excesses that have built up from this vastly overextended credit-fueled global economy.

Imagine a forest where there has been no forest fire for many, many years. The longer it continues like that, the more the underbrush builds up and the more vulnerable the forest becomes to a fire. Not only does it become more vulnerable, but if a fire does begin it's likely to be much bigger than it would otherwise have been.

When in a state of undisturbed nature, forests have periodic fires which tend to be relatively small and over relatively quickly but which serve a purpose—to clear out

the underbrush and prepare the forest for the next stage of growth. For a long time the U.S. Forest Service would quickly extinguish these natural periodic fires. But then they found that by quickly extinguishing these smaller, natural fires they were making it possible for much more massive fires to occur.

Such natural fires burn more frequently, yes, but also, due to less underbrush, they tend to be small and self-limiting. As mentioned above, if such smaller fires are quickly extinguished *then it is likely that even larger ones will eventually follow.*

This same principle is playing out currently in the global financial world. We could say that, by stepping on the gas of money and credit creation, the financial system has prevented smaller fires of recession/depression from occurring but in the process has made it a great deal more likely that a much larger financial and economic tsunami will occur.

For example, in the 1987 stock market crash the market went down about 22%. Normally, this would have led to a recession. But the Fed poured enormous amounts of monetary reserves into the system and the recession was avoided. The same thing happened after the market drop from the top of the bubble in 2000 to the bottom in 2002: Normally, this would have led to a depression—because the financial bubble in 2000 was much larger than the one in 1987. But the Fed would not allow it.

Once again it flooded the system with new fiat money and this time blew a gigantic housing bubble from 2002 to 2007. Other examples of this process could be given.

As a direct result of not accepting the recessions we should have had, or to the extent that we should have had them, the system has now become vulnerable to a much bigger crash. In such circumstances a small implosion, from whatever source, can quickly gain momentum and lead to something much more severe.

Will the Fed and other central banks allow the full downcycle this time? They will certainly try to quickly extinguish it by injecting even more fiat money into the system, a process which, as we've seen, ultimately leads to hyperinflation. Whether they will succeed this time in staving off the downcycle is an open question.

Once a crash of a huge financial bubble gains some momentum it becomes very difficult to stop. The Fed can increase monetary reserves, but ultimately, new money entering the system depends on new credit entering the system. If banks and other financial institutions become more leery of extending credit, as is happening now, the system can potentially freeze up and the exertions of the Fed and other central banks can become like pushing on a string. We'll see.

In the financial world, as with the forests, it's wiser to allow the natural rhythm of periodic small recessions to occur, since if these natural fires/recessions are staved

off then the misalignments and excesses of the system build up further and the financial system becomes prone to a much deeper recession. And if such a deep recession is also staved off then the system becomes increasingly prone to a crash and deep depression.

Such a crash is unpalatable to both politicians and the public, so the financial bubble blowing will continue higher and higher until it ends, as virtually all historical examples have ended, in some *extreme outcome*—either a hyperinflation or a depression or both together. (Note that a hyperinflation is also a depression, though not of the classic kind. A hyperinflation becomes an economic depression after awhile *because the value of money itself is being destroyed.*)

As mentioned before, this financial bubble blowing used to happen in individual countries, such as France in the 1790s, the United States in the "Roaring 1920s" or Argentina in the 1990s. But now this process has been happening in every corner of the globe.

Therefore the resulting extreme outcome—either hyperinflation or depression—will also likely be global in nature when it arrives. It could even be both at once, as in the 1970s—when prices climbed even as the economy faltered—though, given the size of the current bubbles, this possibility would be much more severe this time.

To sum it up, this highly vulnerable and unstable financial system will resolve itself in one of two ways:

Either the higher and higher bubbles will resolve into a runaway inflation, where the value of money—and the middle class as well—is systematically destroyed. Or, at some point before then, a classic crash and depression could ensue, where the debt is resolved through a series of failures and bankruptcies. As mentioned, it's even possible that both could occur, an inflationary depression.

Note, though, that however things go, the endgame of this process is a drastic fall in the standard of living. The U.S. and the Western world have gone into such huge financial overshoot that an extreme outcome has become almost inevitable. (Farther on, we'll look at this phenomenon of overshoot in other contexts.)

This extreme economic outcome will very likely be preceded by an extreme outcome in the world's stock markets. Yet this too could be one of two types: a classic crash, where the markets collapse and usher in a classic depression, or an inflation-adjusted crash, where stock markets go up in nominal terms while melting down in inflation-adjusted terms.

The latter is what occurred in Germany in the early 1920s: The stock market climbed to the sky in nominal terms but collapsed over 90% in inflation-adjusted terms. And of course the currency eventually became worthless. In this process the middle class lost its life's savings and became impoverished, which paved the way for Hitler. But that's a story for another day.

In the volatile financial and economic environment we're heading into, the precious metals may give the best potential to preserve some purchasing power, whichever way things go. Gold/silver have performed this function many times in history, and likely will do so this time as well. A position can be taken through exchange-traded funds (ETFs). But sooner or later physical possession of coins or bullion will likely be necessary.

A crash is certainly threatening. A growing number of financial institutions have been affected so far by the increasing credit crunch, including Citigroup and Merrill Lynch, which have taken large losses, and New Century Financial and American Home Mortgage, two mortgage lenders which both recently went belly-up.

This story is almost certainly just getting started. And it could turn into the greatest financial/economic collapse in history. Of course, if that happens it will be blamed on some proximate event such as a large bank failure or the fall of the dollar. But if we look deeper, such an event would actually arrive courtesy of the epic and unprecedented debt bubble which preceded it.

Or—central banks could pump in enough liquidity to take us on another round of bubble blowing. However, sooner or later the piper will have to be paid.

That's the big picture financially. Now let's look at global geopolitics . . .



4. GEOPOLITICS I

The financial and geopolitical worlds are converging in part because they're both so overextended and in part because they're both heading into a crisis. Indeed, those are two ways of saying the same thing.

The geopolitical situation reminds me of the period just before World War I. Countries were rearming themselves at a frantic rate, tensions were strongly rising behind the scenes, yet all countries professed a tremendous interest in diplomacy. It only took a spark to set off a conflagration.

China is heavily arming itself, and its actual military expenditures are estimated to be at least double the published figures. Russia is rapidly rearming and has just suspended its participation in the Conventional Arms Treaty in Europe. Of course the U.S. has repudiated a number of arms-control treaties in the last few years and

has drastically increased its Defense Dept. expenditures. Turkey has recently moved 140,000 troops to the border with Iraq. Japan is rearming for the first time since the Second World War.

In addition, Russian nuclear-armed bomber flights have just resumed over the Atlantic and Pacific oceans, replicating a Cold War operation not seen in 15 years. Recently, as well, Russia and China and the other nations in the Shanghai Cooperation Organization staged joint military exercises. This cooperation between the Russian and Chinese militaries is a striking development.

A second U.S. carrier battle group is now stationed in the waters near the Persian Gulf and a third is on its way. U.S. anti-missile batteries are being installed in the Sunni-dominated Arab states surrounding Iran. For its part, Iran has installed Russian-made Sunburn missiles all along the Persian Gulf and has also just tested a new missile which can hold a nuclear warhead.

It's quite conceivable that the Bush administration could bomb Iran at some point before the end of 2008, in spite of any "diplomatic" feints. The situation is eerily reminiscent of the runup to the U.S. invasion of Iraq. All the talk is about "diplomacy" while the combatants-to-be continue to move their military forces into place.

The U.S. bombing attack, if it comes, will almost certainly be quite massive and directed not just at Iran's nuclear installations but also at its entire military infra-

structure. Such an attack could be ordered at any time.

The aftershocks of such an attack, were it to occur, would be absolutely enormous. The U.S. is in a far weaker position now than it was in 2003—its military now overstretched, its debt-ridden economy dependent on foreign lenders, and its moral position in tatters from Guantanamo, Abu Graib and the willful neglect of the environment. As well, the U.S. has seen its diplomatic standing sharply diminished from its misadventure in Iraq and its unilateralist international stance.

That's not even to mention the profound energy dependence of the U.S. and the West in general. With the U.S. importing 2/3rds of its oil, that position is an extremely fragile one. Thus the blowback to U.S. interests from an attack on Iran would be much greater than the already catastrophic effects of the invasion of Iraq. Energy prices, and thus pressures on Western economies, would rise even more dramatically. And the U.S. would find itself even more isolated than it is already.

As a counterpoint to the unipolar power and recent pugnaciousness of the U.S., a bloc of other countries is quietly coalescing. This bloc is basically consolidating in the East, led by Russia and China, but also includes India, Iran, and a rising number of allies in S. America, Central Asia and elsewhere. This Eastern bloc of nations is emerging as a response to the worldwide nervousness over recklessly-used U.S. unipolar power.

The deepening polarization is leading to a renewal of the Cold War—a Cold War II—between an increasingly isolated U.S. bloc and a growing Russo-Chinese-Eastern bloc. This process is already occurring but will probably accelerate. Odds of this Cold War II eventually heating up into a regional or even global hot war are not insignificant, especially as the U.S., its power slipping away from mostly self-inflicted wounds, is not likely to enter the endgame without a fight.

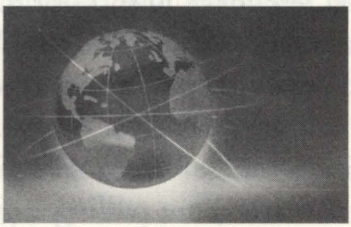
This Cold War II is currently being fought, as the first Cold War was, via proxies—as is occurring now in Africa, the Middle East, the Caspian Basin and elsewhere. However, as the new Russo-Chinese-Eastern bloc of power coalesces—and the scramble for global energy and resources increases—tensions between the two blocs of power will also increase, leading potentially to a "perfect storm" of war at some point.

Further, al Qaida, Hezbollah and related terrorist organizations are increasingly acting as proxies for the Russo-Chinese bloc. They aren't doing this deliberately, at least not at this stage, but as the analyst W. Joseph Stroupe points out, the harm inflicted on the West by terrorist actions will ultimately benefit Russia, China and their allies, since they will step more and more into the power vacuum created thereby. Indeed, they are already doing so as U.S. power declines.

On an external level, then, it seems that the world,

and particularly the U.S., is standing on a financial and geopolitical precipice and not too far from slipping off. Though this picture is a grave one—and we haven't even talked yet about the unfolding ecological catastrophe—it seems necessary to portray it unblinkingly if we're to deal realistically, farther on, with the general principles that might be involved in creating a sustainable world.

Further, this painful and cataclysmic process that the world appears poised to embark upon, and which in some ways is already occurring, also has the potential to result in something constructive—correcting the various imbalances and excesses that have arisen, moving the human journey away from its current posture of hubris towards the natural world, and eventually, seeding the rise of a collective humility, awareness and compassion towards all of existence that is scarcely imaginable now.



5. GEOPOLITICS II

Intimately related to the financial and geopolitical areas is the energy scene. I believe it's safe to say that the majority of the geopolitical tension in the world is ultimately grounded in the scramble to secure and protect vital energy supplies.

All national governments recognize that without energy everything grinds to a halt. But the East is acting on this knowledge in a prodigious way: China's way, and that of other bloc members, is to make deals, period. In dealing with a particular nation China doesn't care about human rights, the ecology, labor matters or anything else. It's not there to intimidate or threaten; it's just there to do business. And it is making energy and resource deals all over the planet to secure reliable supplies.

For instance, China's trade with Brazil has risen *1000 times* since the 1970s. And Latin American exports

to China have increased at a torrid *20% annual pace* in the last seven years.

Similarly, Iran, India, etc. have been busy making energy and resource deals everywhere—and that's not counting all the energy and material resource deals which Russia is making.

What's interesting is that these "Eastern" countries (some of which are in S. America) are pulling together. Not only are Russia, China, India, Indonesia, Iran, the Caspian Basin, Malaysia, Venezuela, etc. pulling together geopolitically and diplomatically, but to some extent they are doing so as well in energy and finances.

Not only are Eastern nations making all sorts of cross deals among themselves in energy and resources, but there is also talk of eventually forming a region-wide currency. It's also interesting that the Eastern world is piling up financial reserves through trade surpluses with the Western world. While the Western world is, in general, sinking deeper into trade deficits, the Eastern world is accumulating financial assets, and increasingly physical assets too, across the planet.

Also contributing to the polarization between the Western and Eastern poles is a frantic military buildup going on in China, Russia, Iran and so on. These nations are not innocent victims by any means, but it's also true that they have become deathly afraid of, and angry over, the arbitrary use of U.S. military power. In any event,

there are numerous cross agreements being signed in the Eastern bloc concerning their military cooperation.

Strategically, throwing its weight around has cost the U.S. dearly, most of all in fostering this coalescing Eastern bloc spearheaded by Russia and China but also including a number of other nations. The increasing polarization occurring between this Eastern bloc and the U.S. is palpable.

As said earlier, the two blocs are already in a kind of Cold War through their proxies—Iraq, Lebanon, the "color" revolutions in former Soviet states and so on. This Cold War II, which is on a relatively low burner now, could, because of rising polarization, heat up at some point into one or more hot wars on a regional or even planetary scale.

On the other hand, humanity could get lucky and realize that its very existence is at stake in the continuing ecological devastation occurring on planet earth. This realization, if it goes deep enough, could cause humanity to pull together globally to save itself and the diverse web of life on earth.

Another possible source of pulling together could be humanity's increasing realization that it is being displaced in its planetary dominance by another lifeform—computers—whose intelligence is growing by leaps and bounds. Potentially, this could precipitate a profound realization at some point that our common humanity is

greater than our differences as individual humans.

Yet another possible cause of the pulling together of humanity would be the emergence of large-minded political leaders who appeal to our common humanity—and our common work in the planet's sustainability—rather than appealing to lesser identifications such as the nation or the party or the tribe or the ideology.

Such leaders would repeatedly call attention to our common humanity, to our preciousness as human beings, to our common work in grappling with ecological, energy, water, poverty and other challenges on a global scale. They would emphasize that we can pull together as a common humanity because our challenges require it.

If we identify principally with our nation, our tribe, our religion, our political ideology, etc. in the years to come, we are likely to give way to increasingly polarizing forces now occurring in the military, energy, diplomatic, financial and other spheres.

On the other hand, if recognition of our common humanity and common challenges comes—and comes soon enough—we could emerge into a different kind of future where we become the living beating heart of a sustainable planet.



6. ENERGY & COAL

As we've seen, energy is one of the most fundamental threads of the world's interlinked fabric. Solving humanity's energy challenge is, of course, intimately related to solving its climate and ecological ones. It is also intimately related to various geopolitical tensions across the globe—whether in a "cold" or "hot" phase. In addition, the price of energy profoundly affects the world's financial and economic systems.

So let's now take a look at what might be the most elegant and satisfactory solutions to humanity's energy challenge. First of all, what is that challenge?

It has two parts: The first part is that humanity is running out of cheap fossil fuels. Note that the last sentence doesn't say that humanity is running out of fossil fuels. It is indeed, but that's something that's going to happen down the road. What's happening right now is

that humanity is running out of *cheap* fossil fuels—and that is already having a deep effect on global financial, ecological, diplomatic and military areas.

The second part of humanity's energy challenge is the effect that our extraction, processing and consumption of energy is having on the planet's biosphere—the thin planetary crust where all life takes place.

The crucial concept of EROI—energy return on energy invested—is the ratio of how much energy we're getting back versus the amount of energy that has to be invested to get the energy.

For instance, in the early years of the Petroleum Age humanity had suddenly discovered an energy elixir, because the EROI of oil was over 100 to 1. Humankind was getting back 100 units of energy for each unit of energy invested. We were going after the low-hanging fruit: the oil that was the cheapest and easiest-to-obtain. Our energy return on energy invested was fabulous, and humanity threw a great energy party that has lasted for over a century now.

But sooner or later we must make the transition away from fossil fuels and towards more sustainable sources of energy, both because we have to live on this planet that we're despoiling and because our EROI on fossil fuels is steadily falling.

As we extract petroleum and other fossil fuels from increasingly difficult and harsh environments, the EROI

on global oil is estimated to have fallen from 100 to about 18. We're still obtaining about 18 units of energy from petroleum for every 1 unit of energy invested to get it, but the ratio is falling with every passing year. This being so, regardless of when we "run out" the writing is on the wall for fossil fuels. What will replace them?

Before looking at the alternatives to fossil fuels, though, we should deal with the largest and oldest fossil fuel: coal. Humanity has more than enough coal to power its energy needs for centuries—so what's the problem? Of course, the problem with coal is that it releases twice as much carbon dioxide as oil for an equivalent amount of energy.

In spite of that, coal has become the fuel of choice in generating plants across the globe because it produces power relatively inexpensively. China alone installed an estimated 80 megawatts of new coal-fired plants last year alone, which is more than all the power generated in the United Kingdom.

All these new coal-fired power plants are going to create an absolute tsunami of global warming and other climate change unless some way can be discovered to sequester the carbon dioxide produced by coal and then bury it deep in the earth. Such a process is considered technically feasible, but it has not yet been commercially demonstrated.

The Texas energy utility TXU, after its takeover by

equity funds allied with "green" organizations, has now announced that it will build two experimental coal-fired generating plants designed to capture and sequester carbon dioxide. American Electric Power has announced a similar demonstration plant. All of this is good news and hopefully the beginning of a trend.

Yet even if this expensive "sequestration" strategy were to become globally prevalent—itself a tall order—I don't think that coal can be a significant part of a long-term solution to humanity's energy challenge. The primary reason, perhaps, is that the amount of sequestration we're talking about is enormous.

For example, as the analysts John Deutch and Ernest Moniz point out, a standard 1,000 MW plant would have to sequester, during its 50-year lifetime, over a billion barrels of highly-pressurized gas—and many hundreds of such plants would be needed to even begin making a real difference in the CO2 reaching the atmosphere. So we're talking about sequestering trillions of barrels of highly-pressurized gas. Hmm.

Well, instead of burning something toxic and then trying to deal with the enormous waste-disposal problems thereby created, it would seem to make more sense, long-term, to focus on those ways of producing energy that are *inherently* clean, sustainable and renewable. I do feel confident that clean and renewable energy generation will eventually prevail almost completely in human

society, for the simple reason that otherwise life on earth may become unsustainable.

Now let's take a look at the subject of renewable energy from a somewhat different perspective—the *long-term* efficacy of each of the various forms of alternative energy in solving humanity's energy challenge.



7. ENERGY & BIOFUELS

Energy from *biofuels* is now getting a lot of buzz everywhere: Ethanol from corn, sugar, cellulosic grasses, even trees. Biodiesel from natural crop oils and even used cooking oil. Instead of importing oil we grow it instead. And on average it produces fewer greenhouse gases than petroleum. What's not to like?

Though the various biofuel schemes may appear attractive on the surface, I believe there are several long-term problems with them. For these reasons, considered below, it seems to me that biofuels will likely be only a first-generation alternative fuel, perhaps supplanted in time by more viable and sustainable energy resources.

First, a problem with some biofuels is a low *energy return on energy invested* (EROI). The most optimistic assessments of the EROI of corn-based ethanol, for example, are 1.3-to-1. That is, to get 1.3 units of ethanol

out you have to invest 1 unit of energy in. That's a poor deal, a minuscule return on energy invested. Compare it to the 18-to-1 current EROI of petroleum.

Corn from industrialized farming methods requires tremendous amounts of oil for planting, harvesting and transporting. It uses fertilizers and pesticides made from natural gas. When you add up all the energy invested to get the ethanol you're only getting a little more energy out than you put in.

Second, ethanol from food crops—such as corn—has the potential for deleterious effects on the price and supply of food. There is only so much suitable agricultural land on the planet and almost all of it is already being used for food crops. Thus ethanol from food crops can place further pressure on an already-strained world food supply.

What about ethanol from sugar then? Sugar-based ethanol, as made in Brazil, has a relatively decent EROI of around 4.7 to 1, vastly better than corn ethanol.

Yet ethanol from sugar also has the problem that it is competing directly with food crops for land and water. Sugarcane is a very water-intensive crop. Moreover, the clearing of land in Brazil to grow sugar for ethanol has been a major driver in the deforestation of the Amazon.

An intriguing possibility is producing ethanol from cattails grown in wetlands or sewage treatment plants. Ethanol from cattails would have the advantage of not

competing with croplands for food. And studies suggest cattails could perhaps produce 1,000 gallons of ethanol per acre, far more than ethanol from food grains.

But the real promise of ethanol, it seems to me, will come from *cellulosic ethanol.* This is ethanol that, instead of being made from the sugar or starch of a plant, is made from the cellulose that holds the plant together.

The first advantage of cellulosic ethanol is that it is capable of relatively high energy returns. Initial studies have yielded an EROI of roughly 3-to-1, but researchers believe that this can be greatly increased over time.

An interesting fact about cellulose is that it is often considered the *waste product* of the plant. If we could perfect cellulosic ethanol we could grow corn, for example, first for food—20% of the plant—*and use the other 80% of the plant to produce ethanol.* After the process to produce cellulosic ethanol, what's left is called *lignin* and can be burned to provide the energy for the process. Notice that the entire operation can be self-energizing now and that *we're using the whole plant for the first time.*

The big challenge with cellulosic ethanol is that the cellulose must be broken down into simple sugars so that the fermentation process into ethanol can begin. Right now there are two main processes for doing this, acidic hydrolysis and enzymatic hydrolysis, and neither one has been proven on a commercial scale.

The breakdown of cellulose by enzymes is probably

the more promising of the two processes, since it holds the potential of being combined with fermentation to produce a one-stage process in which bacteria convert cellulose to ethanol in a single step. Lee Lynd and his colleagues at Dartmouth are showing progress in making this technology, called *consolidated bioprocessing*, a reality. Yet it is still quite a way from being viable.

Successful commercialization of ethanol produced from cellulose would bring big benefits, since everything from corn stalks to grass clippings to sawdust to paper sludge could be turned into ethanol.

According to scientists, probably the best candidate for cellulosic ethanol is a plant known as *switchgrass*. It is a grass that grows quickly, is not a food crop, and uses water efficiently. But even ethanol from switchgrass has two possible drawbacks, namely that it could potentially compete with food crops for land, and especially, water. This will be discussed further below.

Another interesting biofuel is biodiesel. Biodiesel is made from plant oils. Examples are soybean oil, canola oil, palm oil, etc. Biodiesel can also be made from waste vegetable oil (WVO). It can also be made from various animal fats such as lard, grease, chicken fat and so on.

Biodiesel can be used in any diesel engine, in any combination of percentages. Biodiesel also has the great advantage that it can be transported through the existing infrastructure. Ethanol cannot be transported by pipeline

because it attracts water and becomes contaminated. So it must be transported by truck. In contrast, biodiesel easily moves through pipelines.

Another advantage of biodiesel is that it has almost as much energy density as gasoline, whereas ethanol has only 66% of the energy density of gasoline. Thus, even after accounting for various factors, about 25% to 35% more ethanol must be burned to produce the same net amount of energy. In contrast, biodiesel matches gasoline gallon for gallon (within 2%) in producing energy.

Another factor is that diesel engines are about 20% more efficient than gasoline engines. This means, if we include energy density considerations, that a gallon of biodiesel will power a vehicle approximately 20% farther than a gallon of gasoline and almost 60% farther than a gallon of ethanol.

Diesel fuel has a reputation in the U.S. as a dirty fuel, but biodiesel is another story. According to a 2006 study in *Proceedings of the National Academy of Sciences*, biodiesel emits lower levels of pollution (41% less) than ethanol (12% less) or gasoline.

But even biodiesel, seemingly desirable as it is, may only be a first-generation solution—because, like other biofuels, it has the potential to compete for fresh water and agricultural land with human needs. In the long term that need for water, in particular, will almost certainly collide with humanity's requirement—as the planet heats

up and the human population rises—for increasingly scarce fresh water.

The availability of water is not a mainstream topic as yet, but it will be. The recent *Intergovernmental Panel on Climate Change* report, compiled by 1,000 scientists worldwide, says that by 2025 "hundreds of millions" of people won't have enough water, that by 2050 over one billion people will be so affected, and that by 2080 up to 3 billion people won't have enough water. Fresh water is destined to become a critical issue on planet earth. So a continuing challenge for biofuels will be their potential to contend with food crops for fresh water.

Another potential challenge of crop-based fuels is the argument that, even pushed to extremes, they could make only a relatively small dent in the thirst for energy. For example, the U.S. Dept. of Energy estimates that, even if an all-out effort were made, ethanol could only supply about 10-15% of the nation's need for gasoline.

The green analyst Lester Brown points out that raising U.S. fuel efficiency standards just 20% "would contribute as much as converting the entire U.S. grain harvest into ethanol." Similarly, even if we converted all the vegetable oil in the U.S. into biodiesel it would supply less than 10% of the U.S. need for diesel fuel.

Though they produce higher energy returns, even cellulosic ethanol and biodiesel from high oil crops (such as palm oil) run into a similar problem: There just isn't

enough agricultural land in the U.S. or in the world for biofuels to make more than a relatively small dent.

The exception might be *biodiesel from algae.* If we look at the gallons of fuel per acre of various crops, we find canola oil at 127 gallons per acre, the jatropha plant at 202 gallons per acre, the oil palm at 635 gallons per acre and cellulosic ethanol, if brought to its full potential, perhaps 1,000 gallons per acre.

But algae is capable of supplying anywhere from *5,000 gallons to 20,000 gallons of fuel per acre.* It's a whole other ball game. Even using the lesser figure, just 6% of the farm land in the U.S. could supply all its liquid fuel. And algae can grow almost anywhere: shallow ponds in the desert or even in human sewage. The ultimate may be algae in wastewater treatment plants, cleaning the water while yielding huge amounts of biodiesel. This has just been demonstrated for the first time in New Zealand.

Also of tremendous promise is *permaculture.* In this way of life, food-growing, energy-producing and other human systems are designed to imitate the processes of nature by incorporating diversity and *closed loops*, that is, processes where the output, waste or pollution of one area becomes the input to other areas. This can increase the energy return of biofuels while facilitating a human union with nature. More on this later.



8. ENERGY, WATER & WIND

As Alex Kirby tells us, "Global water consumption rose sixfold between 1900 and 1995—more than double the rate of population growth." In addition, humanity's water requirements continue to grow—"as farming, industry and domestic demand all increase."

So far, humans have been doing a short-term fix on this by drawing their water from underground aquifers—aquifers that were formed over countless millennia and now are being drawn down in a few decades. We're eating our seed corn, to mix metaphors, and water tables in the U.S., China, India, Russia and West Asia are all dropping.

Agriculture already uses 70% of all the water consumed worldwide—and, with the exception of biodiesel from algae, we may not want to put further strains on earth's fresh water supply with biofuels. Let's remember,

earth's fresh water supply has to provide for not just us humans but also all land-based life, including both plant and animal life.

For a similar reason, hydropower may also become less important as time goes on. Long-term, as the planet becomes hotter and drier, water will likely become way too precious to divert to water-intensive energy from hydropower, except in relatively token amounts.

Some optimists point to desalinization as the key to humanity's future water supply. Maybe. But desalinization has huge drawbacks itself—in addition to leaving huge amounts of brine, desalinating water requires huge amounts of energy.

Ah, there's our old friend energy again. Water is connected to climate change is connected to energy is connected to the financial system is connected to geopolitics and on and on. It's all connected now, and the entire system will most likely have to be solved as a whole if it is to be solved at all. That is, the entire human enterprise will probably have to shift to some kind of sustainable basis if, long-term, human and other life is to continue on planet earth.

What about energy from fusion? Humanity has pursued the dream of controlled power from atomic fusion—the same reaction that powers the sun and the hydrogen bomb—for over 50 years now. And yet any practical application still seems at least 50 years away.

A speculation: Not only will controlled fusion be solved at some point, but the day may even come when a fusion generator is no larger than a battery. But that time, I imagine, is way, way off and is probably more in the realm of science fiction than serious prediction.

And I must admit to a bias about something. All the fuels we've considered so far are all really just stored sunlight. It's true of petroleum and it's true of biofuels. Even with ethanol from cellulose or biodiesel from algae we have a very complex process to turn the plant into fuel. Moreover, photosynthesis converts only 3% to 6% of available sunlight into usable energy—compare that to solar cells which can now operate at 20% efficiency in capturing the energy in sunlight.

Why not harvest sunlight more directly then?

This brings us to what are probably the two most promising candidates for a deep solution to humanity's energy challenges—wind and solar. Let's now take a look at them in terms of their long-term potential.

Wind, I must say, has some mighty advantages as a sustainable power source: Except for the manufacture of turbines, it is almost completely "clean." It is completely renewable. It does not take precious water. It's EROI is quite good. And its cost, though not yet competitive without subsidies, continues to drop with each passing year. Yes, wind can be intermittent, but the development of better batteries should take care of that.

Combining solar and wind is also a fruitful idea. The days that are bad for wind—bright, clear, sunny—are good for solar, and vice-versa. Experiments in Spain and elsewhere have demonstrated that this combination can provide remarkably stable supplies of energy.

What could really make a difference is when the electricity grid goes global, which can only be a matter of time. A think tank called The Global Energy Network Institute is exploring this idea. What this means is that direct current (DC) transmission lines would cover the globe, taking energy anywhere it's being produced to anywhere on the planet where it's needed.

This scheme would use DC power instead of AC power because DC power can travel extremely long distances with very low loss of power. Thus energy being generated by wind farms in Siberia, North Dakota or offshore, for example, could be gathered and sent anywhere on the globe that needed energy. Similar considerations could apply to solar-generated power.

Wind will certainly make a great contribution to the planet's sustainable energy needs. But long-term, due to possible geographic limitations, it may not become humanity's primary sustainable energy source.

That role will almost certainly go to solar power.



9. ENERGY & SOLAR POWER

It seems to me that solar power will over time become the established leader in providing humanity's energy needs, because it will be likely to provide the most advantages while posing few if any drawbacks.

Solar power is the direct mainline. Wind power ultimately derives its energy from the sun, but it does so indirectly. Biofuels derive their energy from the sun too, but like wind they do so indirectly. The same for tidal energy and hydropower. And of course petroleum derives its energy from sunlight as well—but again, indirectly. The tremendous advantage of solar power is that it isn't wasting energy going through indirect mediums. Solar power is being made *directly* from the sun.

Because of that fact, power from solar cells has a number of powerful advantages: It is about as clean as a technology can get. Once put into operation, it produces

no greenhouse gases or other noxious emissions. Also, it is renewable every morning when the sun rises. And in general, it is not competing with humans and/or crops for water or land.

Also important, solar cells can provide power in both very large settings and very small ones—and everything in-between—from power plants to little gadgets. In other words, solar power is not only sustainable, clean and renewable, but extremely flexible as well.

There are two key statistics to keep in mind concerning solar power:

1) energy efficiency, and 2) cost-per-watt.

When silicon solar cells were first invented at Bell Labs in the 1950s, their energy efficiency was only about 6%. (That is, of the solar energy falling upon the solar cell, 6% was being converted to useful energy.) Now, on average, solar cells are about 15% efficient, a figure that is slowly but steadily rising.

The second important statistic is the cost per watt. That number has made enormous strides, falling from $200 per watt half a century ago to about $4 per watt now—a *50 times* reduction in just 50 years—a remarkable achievement. Many experts now expect the cost-per-watt of solar to match that of the electrical grid within a few years. That in itself will cause a revolution.

The real promise in the field is coming from what are known as "thin-film" solar cells. Standard solar cells

are made from the same silicon that goes into computer and memory chips. Consequently, because of the competition for silicon, there is currently a worldwide shortage of that material.

Thin-film solar cells use less than 1% of the silicon needed in ordinary silicon cells, so that the whole silicon-shortage issue goes away. And thin-film cells also have two other significant advantages:

First, their energy efficiency has reached roughly 20% now and is rising. (Experimental "triple-junction" cells have reached almost 40% in the lab.) Second, since thin-film solar cells are "printed," in effect, on thin flexible materials they could eventually be produced using a technology similar to today's high-speed web presses which print millions of newspapers every day. Thin-film high-efficiency solar cells will probably be manufactured some day in enormous quantities at a fraction of the cost of solar cells today.

When that occurs, the cost-per-watt of solar cells will be far below the cost of electricity from the grid—at which point a real transformation will occur. Cheap, high-efficiency solar cells will become absolutely ubiquitous, and in combination with improved battery technology, will likely become the energy source of choice: providing clean, renewable and low-cost power just about everywhere. This will surely not happen overnight, of course, but does seem quite probable long-term.

Then mesh that notion of ubiquitous solar power —and potentially, stable wind/solar combinations—with the notion of a worldwide electrical grid spanning the globe. Now we have the vision of a world that provides sustainable energy from anywhere—perhaps solar power from the Sahara Desert, wind power from Siberia and so on—and delivers that energy through high-voltage DC lines to anywhere on the planet where it's needed.

In addition to being an integral part of the global energy grid, solar will also probably go more and more "local" too, in the sense of powering all sorts of local things locally. It's likely that solar cells could become just as completely ubiquitous in the future as computers, robots and adaptive networks.

Complementary to solar technology will be cheap and highly efficient batteries and capacitors—the latter enabling solar power to potentially be easily stored and drawn down as needed. A breakthrough at Rensselaer Polytechnic Institute recently will enable batteries and capacitors to be inexpensively "printed" on thin sheets of cellulose which then can be folded or cut up without affecting performance. And the sheets can be stacked to create greater amounts of power or storage.

Very promising. Yet, as we'll see later, technology by itself cannot solve humanity's challenges.



10. ENERGY & HYDROGEN

If solar power is one wing of the ultimate renewable energy solution, then hydrogen is probably the other. As discussed, thin-film solar cells of all sizes and shapes will energize everything from houses to power plants to all sorts of gadgets. But what it probably will not power is the transportation system. For that purpose, hydrogen may eventually be ideal.

Hydrogen is not an energy source, but rather, an energy carrier. Energy must be expended to obtain free hydrogen, but once obtained it has many advantages.

For example, when hydrogen is used in a fuel cell, energy is released with only water and heat as the by-products—no carbon dioxide or other pollutants are emitted. And if the hydrogen itself is produced by a renewable energy source such as solar, wind or geothermal power, then the energy (except for the original man-

ufacturing processes) becomes virtually carbon-free and pollution-free.

But hydrogen still has significant technological hurdles to overcome. The foremost of these hurdles is volume. Though hydrogen by *weight* has an energy density 3 times that of gasoline, by *volume* gasoline is normally 3000 times more dense than hydrogen.

To overcome this limitation, hydrogen must be condensed somehow into a much smaller volume. Otherwise the fuel tank, in order to obtain an acceptable driving range of 300 miles, would have to be many times larger than the car itself. So engineers are looking for ways to condense the hydrogen.

The most direct way to obtain this condensation is to compress the hydrogen gas to several hundred times atmospheric pressure (5000 to 10,000 psi). But this extremely high pressure creates problems of its own, particularly in handling and refueling. Moreover, even at such prodigious pressures hydrogen still has only 15 % of the energy density, by volume, of gasoline.

So researchers are looking beyond simple compression. One possibility is to cool the hydrogen gas down to -253 degrees, when it turns into a liquid. Liquid hydrogen has a high energy density and volume density, but because it must be kept at such a frigid temperature huge challenges of refrigeration and handling become paramount. In addition, it takes a lot of energy to make and

keep hydrogen that cold, so the energy return on investment goes way down.

A more promising alternative is to use *metal hydrides,* as described in *Scientific American,* which absorb hydrogen into their molecular structure similar to the way a sponge absorbs water. Metal hydrides can achieve volume densities even higher than liquid hydrogen and are stable in storage. Unlike liquid hydrogen (which must constantly use energy to stay frigid), metal hydrides can store their hydrogen without added inputs of energy.

The big downside of metal hydrides is that they need a very high temperature (around 700 degrees F.) to release their hydrogen. This shortcoming can be overcome by using so-called *complex hydrides,* which release their hydrogen at a much lower temperature. However, they were thought until recently to require refueling in a factory.

Then, just in the past few years, *reversible* complex metal hydrides were discovered, which would allow autos to be refueled at the local service station. This is a very promising area, and though it's not quite ready yet, auto companies—including Toyota, Honda and GM—are pursuing it with vigor.

Other promising areas of development are storing hydrogen in liquid *chemical hydrides* and in exotic *carbon nanotube* structures. Time will tell which of the technologies mentioned above will become the most effica-

cious, but it seems only a matter of time until the challenges of hydrogen storage are solved.

Then there's the challenge of infrastructure. Factories, refineries and delivery systems must be built, and tens of thousands of service stations must be converted to hydrogen delivery. All of that will take time, and so will the engineering challenges, so that humanity in the meantime may suffer through an *energy deficit* for some time as cheap fossil fuels become more scarce and alternatives have not yet fully come on stream.

A recent development which holds promise perhaps is the burning of salt water for fuel. John Kanzius, a cancer researcher, discovered that if salt water is exposed to intense radio waves that the water will actually burn. Apparently, the radio waves loosen the chemical bonds between hydrogen and oxygen and cause them to ignite. However, so far this process has a negative energy return on energy invested, and may always, so this development may or may not amount to something.

However, a day will likely come when the technical challenges of solar cells, fuel cells, hydrogen and so on are solved. We can envision a future when humans power their homes, vehicles, buildings, etc. in ways which are truly benevolent to the biosphere and all life within it. The challenge will come in crossing the deep energy and ecological deficits that loom between here and there.



11. ENERGY SOLUTION TYPES

The ankle bone is connected to the calf bone is connected to the knee bone, etc. It's all connected. The different parts of the brain are wired together. The different parts of the biosphere affect one another. Events in geopolitics can affect the financial markets and vice-versa. Events in energy affect the economy, the financial markets and the climate.

A planet with a fever is causing various rivers and lakes around the world to reach a "crisis point," according to the World Wildlife Fund, including such major rivers as the Yangtse and Mekong in China, the Ganges in India, the Danube in Europe and the Rio Grande in North America. As another example, the huge Lake Chad in Africa has lost 80% of its water in just the last four decades. Underground aquifers are falling steadily around the world.

Desertification is spreading in many areas of the globe, including sub-Saharan Africa, northern China and the western U.S. The increasing preciousness of fresh water, in turn, affects choices among food crops, energy supplies and geopolitical/military considerations. And all of that affects financial markets and economies, which affect the climate and so on—an interconnected round robin.

As discussed previously, humanity is likely standing on a precipice in financial, economic, military and ecological terms as well as in others. For example, humanity is quite likely to witness the greatest financial implosion in its history. Also, military tensions are on the increase as "defense" budgets increase everywhere and nations scramble for precious energy.

In terms of energy, it seems likely that humanity will experience an energy deficit for awhile as supplies of fossil fuels become more scarce and alternative energy technologies take time to ramp up. This "energy dip" and "financial/economic dip" and "fresh water dip" and "military dip" and so on all seem likely to happen within the next few years to decades—an array of confluences coming together.

And that's not even to mention the rising of a new intelligence on earth as our computer servants gradually become our masters, as mentioned previously. Yes, we humans seem to be in for some very interesting times.

And while all this is likely to be constructive long-term, it is also likely to be highly stressful in the short-term.

How best to ameliorate this stress?

One obvious place to intervene is in the energy area, first, because technology is fostering a number of hopeful scenarios, and second, because energy deeply affects so many other areas. A genuine, honest-to-God sustainable solution to the energy challenge could be immensely uplifting to the human enterprise.

As a recent issue of *The Economist* points out, there are basically 3 ways for governments to influence energy solutions (and thus indirectly, climate solutions):

Way #1 is to subsidize particular industries. This is generally not a very good idea because politicians and bureaucrats tend to be much less adept than markets in allocating resources. Consider the corn-ethanol debacle now occuring in the U.S., courtesy of gigantic subsidies from the federal government.

Way #2 is for the government to set standards for products and processes. Two examples are fuel-economy standards for vehicles and the proposed requirements for utilities to get a certain percentage of their power from renewable sources. Standards sometimes work, but they still mean trusting politicians and bureaucrats to allocate resources well—often a dubious proposition.

Way #3 is to put a price on the activities/products that are polluting the biosphere; for example, a tax on all

activities and/or products that are releasing carbon into the atmosphere—a *carbon tax.* This would be by far the most difficult alternative from a political perspective, but if it could be enacted—perhaps by coupling it with an elimination of the payroll tax, as Al Gore suggests—it seems the smartest way to go, because it harnesses to the overall goal the power of markets to allocate resources efficiently.

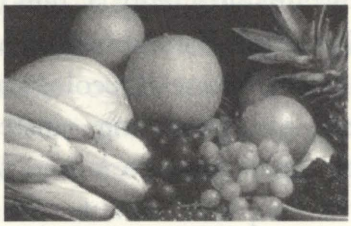
In Way #3 the overall goal tends to be achieved in a way that is more natural and organic than otherwise, since the market itself is allocating how the goal will be reached. In effect, it means that each consumer and each business and each government agency, as they go about their daily business, is automatically making decisions that contribute to the overall goal of lower carbon emissions. It's cool, but difficult politically.

Somewhat more easy politically, and related to the carbon tax though not as elegant, is a cap-and-trade system for carbon emissions. Europe set one up last year: A limit of *so much* overall carbon emission is set, and then allocations for that amount—shares of rights to pollute, in effect—are put into a central market where polluting industries can buy and sell them.

Though not quite as elegant as a carbon tax, a cap-and-trade system does capture the allocation power of markets. In practice, though, some combination of all of the three ways discussed above will likely be used in order

to achieve greater efficiency and innovation in generating and consuming energy.

A positive, global, sustainable energy system would go a long way towards alleviating the stresses of potentially collapsing bubbles in the financial, ecological and geopolitical areas, not least by showcasing—instead of something negative to fight against—a common, worldwide, worthwhile goal to cooperate about and work towards.



12. CLIMATE CHANGE & DIET

We've seen many examples in this series of how so many things are all connected to each other. Now let's look at another, a surprising one.

We may think that our choice of what to eat every day has little to do with global warming, but in fact the opposite is true. Our daily food choices, it turns out, have a profound effect on climate change. Let's see how:

It's not well known, but carbon dioxide is only the most prominent of the greenhouse gases that are causing global warming. To be sure, carbon dioxide is the most important, but the second-most-important—methane—is also crucial.

At first glance methane may not seem all that relevant to climate change, since methane is released each year at a level only 1/200th the level of carbon dioxide. So what's the problem?

The problem is that each methane molecule is 50 times more efficient than each carbon dioxide molecule in trapping heat in the atmosphere. And that's where methane becomes a critical factor. Indeed, methane is estimated to be responsible for no less than *18%* of the global warming phenomenon.

And guess where a goodly portion of the methane released on the planet each year comes from? From cows. That's right, cows, the animals we use to produce milk and meat. Cows—all 1.3 billion of them.

Cows, as it happens, have a different kind of stomach than we humans do. Cows are ruminants, which means that bacteria in their stomach break down their food by fermenting it. And in that process methane is released from the cow's body by burping and flatulence.

Well, so what if a cow releases a little methane? Yet over the course of a year it amounts to a lot of methane, and when we add up all the cows in the world it turns out that in total they're releasing about 100 million tons of methane into the atmosphere every year. And because methane is so potent a greenhouse gas, that is equivalent to *5 billion tons* of carbon dioxide being released into the atmosphere every year. So it's very significant.

But that's not all. On average, as John Robbins points out, it takes 3 1/4 acres of land to feed a meat-eater for a year. To supply a vegetarian for a year takes, on average, 1/2 an acre. And a vegan only requires 1/6 of an

acre. This being so, on average a meat-and-dairy eater requires *20 times* the acreage of a vegan to be fed—and this during a period when acreage for food crops is in competition with acreage for biofuels.

Furthermore, on average the meat-and-dairy eater requires *100 times* the fresh water of a vegan each year (because of the water needed to raise livestock and the grain to feed it). And this is during a time when many parts of the planet are experiencing severe water stress, a situation that is only destined to become more severe as global warming intensifies.

This being so, a vegan is not only making a significant contribution towards reducing global warming, but is also greatly helping to reduce the agricultural and fresh water stress on the planet. And this profound effect is accomplished just by making intelligent choices at the market and restaurant every day!

And even that's not all. Two-thirds of all antibiotics in the United States are now given to livestock, for the reason that the "tight-confinement" methods of industrial farming make the animals very sick, so that the intense antibiotic regimens are the only way to get the animals to stay alive long enough to make it to the slaughterhouse.

Of course, this egregious overuse of antibiotics is helping to generate new classes of "superbugs" that are increasingly resistant to antibiotics. Just recently, for

instance, it has been reported that there is now a strain of tuberculosis that is completely resistant to all known antibiotics. This is a harbinger of things to come in the area of infectious diseases. Eating a vegan diet, therefore, also helps to preserve the efficacy of humanity's arsenal of valuable antibiotics.

And even *that* is not all. A vegan, by requiring much less land, also helps to greatly reduce the intense burden of pesticides and herbicides now fouling our rivers, lakes, coastlines and farmlands.

And a final statistic: The world's cows, just by themselves, consume enough calories to feed nine billion people, almost 50% more than the current human population. As Lester Brown of Earth Policy Institute notes, if American consumers reduced their meat consumption by just 10% it would free up enough food to feed all 60 million of the people who will starve to death on earth this year and every year.

Yes, it's all connected, in all sorts of different ways. In my opinion we humans will sooner or later become primarily vegan in our daily diets not only from increasing necessity, but also from a genuine love of the planet's animals, water, farmland, climate, ecology and, not least, our fellow human beings.



13. CLIMATE CHANGE & TAXES

In dealing with humanity's various interconnected challenges, using the great power and efficiency of the price signal will be quite pivotal, it seems to me. Let's look at an example:

In dealing with the tightly-woven challenges of global warming and the looming energy deficit (soon to be an energy crisis), two promising policy alternatives—as mentioned previously—are 1) *a cap-and-trade system* for carbon emissions or 2) *a tax on carbon* emissions.

A cap-and-trade system, while it partially harnesses the great power of the price signal, also involves very significant bureaucratic involvement by the various governments.

The devil is in the details: After the government sets overall limits on carbon dioxide emissions, the vexing challenge comes in setting the individual carbon

allotments (licenses to pollute) for each utility, auto company and so forth. Yes, the companies can then buy and sell their allotments depending on need, but this doesn't alter the fact that the government is first setting the individual allotments for each company.

The conundrum comes in determining what exactly those individual allotments should be for each company, because setting the quota for each company can lead into a dense thicket of political lobbying and dealing. This in turn opens the door to quotas based on political influence instead of fairness.

And even if political influence is banished—a dubious probability, dear reader—and the attempt is made to set individual caps with scrupulous fairness, it's still quite a difficult proposition. All sorts of considerations enter into a fair determination for each company or industry.

A tax on carbon emissions is inherently simpler and more natural, and thus more fair, workable and effective. Here we just say that for each unit of carbon emitted into the atmosphere a fixed amount of tax must be paid. A 10 cent per gallon tax on gasoline, for instance, would yield about $14 billion a year, according to the analyst Michael Riordan.

An equivalent tax on oil and natural gas used by utilities, buildings and manufacturing plants, etc. would raise roughly twice that amount, or about $28 billion per

year, for a total of about $42 billion annually. And it would do this without getting into the perilous politics of determining individual quotas. Moreover, it could subsidize alternative fuels.

Now let's get a little radical: A $2 tax per gallon of gasoline would raise the price of gasoline in the U.S. to about $5 per gallon—which would still be less than what Europeans pay right now. Add an equivalent tax on the use of oil and natural gas by utilities, buildings, industry and so on and suddenly we've raised about $840 billion annually.

Now remove, say, $90 billion per year to subsidize low-income energy consumers and we're left with a net total of about $750 billion per year, which, as it happens, is enough to entirely replace the personal income tax in the United States.

Replacing the U.S. income tax with a $2 carbon tax per gallon of gas (and its equivalent in other fossil fuels) would thus, in one stroke, replace a convoluted income tax with a revenue-neutral tax that would—merely as all elements of the society go about their daily business—*automatically* and powerfully promote society's twin goals of energy conservation and the implementation of alternative energy.

Such a tax would forcefully—and yet naturally—drive innovations in every sphere of energy use, from energy efficiency in autos, appliances, buildings, comput-

ers, manufacturing and so forth to new developments in renewable energy generation to investment in massive new energy infrastructure.

A carbon tax, though it would face very formidable political obstacles, is worth working for, because it appears to offer a solution that benefits overall societal welfare the most. It would allow governments to set overall policy goals while using the immense power of the price signal to effectively allocate resources.

And if implemented appropriately on a global scale, it would—in the simplest, quickest, most natural and most effective way—powerfully assist humanity in making the wrenching but deeply necessary shift in the way that it generates and uses energy. And of course, our situation with regard to energy will always have a profound influence on our other challenges.



14. EASTER ISLAND I

There are a tremendous number of books and articles out now about the dangers to planet earth, with particular focus on the ecological danger. I would like here to single out two books in particular, from authors who in my opinion have pondered with unusual depth the challenges facing us.

The first book is *Collapse* and its author is Jared Diamond. He is also the author of *Guns, Germs and Steel,* a fascinating story in itself of the rise of human agriculture in particular places and of the continuing advantages that were conferred. However, *Collapse* seems to me more relevant to our current situation because it looks in some detail at a number of societies in the past that failed, and then asks: Why? Why did they fail?

The second book is *The Limits to Growth* (2004 version) and its authors are Donella Meadows, Jorgen

Randers and Dennis Meadows. These authors make use of a sophisticated computer model (called *World3*) which tracks such variables as population, strategic resources, changes in soil fertility, capital growth or decay and other things and how they all interrelate. Then, for each run, they put certain assumptions into World3 and then have it calculate what would happen—population grows *this* much and so on—given those assumptions. The book is a fascinating and extremely well reasoned and balanced presentation.

Inevitably I'll distort the messages of these authors somewhat through simplification, but hopefully not too much. And hopefully too, I can convey some small sense of the essence of what they're trying to say and then link it to some other things.

Let's start with Jared Diamond's great recounting of Easter Island and its inhabitants, from about 900 AD to about 1500 AD. In doing so, we should acknowledge, as he does, the painstaking and heroic work of various archeologists to figure out just what happened there.

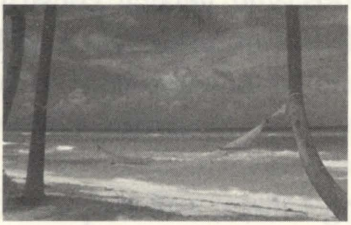
The story of Easter Island is a tale about the most isolated inhabitable island on earth. Easter Island is all by itself, way out in the vast reaches of the Pacific Ocean. Its nearest neighbors are Chile, 2300 miles to the east, and the Pitcairn Islands some 1300 miles to the west. The Easter Islanders existed alone. That's quite important because it means that if the islanders got into trouble

they had nowhere else to go and no nearby neighbors to call upon.

There are a number of examples in history where societies got into trouble but had neighbors nearby that 1) either absorbed them through conquest or 2) offered them assistance by trading with them, thus assuring vital supplies while the society rebuilt itself. But the Easter Islanders had to live or die by themselves. Living out in the remote reaches of the Pacific, they had no other societies to call upon if theirs began to fail.

The metaphor becomes vivid when we look at the situation of planet earth. Earth exists amidst the vastness of deep space. If there are other planets out there like ours—that is, with intelligent life upon them—they are inconceivably vast distances away, revolving around far-distant suns.

In other words, planet earth exists way out in an ocean—like Easter Island—and cannot call upon other planets with intelligent lifeforms if it gets into trouble. Those life-cousins, if they exist, are way too far away. Thus the story of Easter Island, in telling the saga of a society that was isolated out in space, shows what can happen. Easter Islanders, without really meaning to, gradually destroyed their environment—and in doing so destroyed themselves.



15. EASTER ISLAND II

According to archeologists, Easter Island was settled around 900 AD by eastern Polynesians. From the very beginning the island was so remote that there was no connection with another island—no trade, no emigration, no colonization, nothing. The island was alone in space, like our earth.

Easter Island is famous for the great stone statues on it, called *moai*. The islanders built several hundred of them, weighing 10 to 90 tons each, and erected them all over the island without cranes, metal tools or draft animals. These moai represented high-level ancestors, to which the islanders prayed,

When these Easter Island settlers arrived on the scene, the island was covered by dense forests, including 22 different kinds of trees. One of these 22 kinds was a variation of the *wine palm*, the largest palm tree—now

extinct—ever to exist in the world.

The trees provided many services. First of all, they provided lumber for houses and general construction. They provided palm fronds to make thatched walls and roofs and baskets. The trunks of another kind of tree could be made into large seagoing canoes, powered by sails constructed of palm fronds.

With these seagoing canoes, and harpoons made from yet another kind of tree, the islanders were able to hunt a rich assortment of seafood, including porpoises, tuna and other kinds of fish. They also feasted on an abundance of land birds, seabirds and shellfish.

The trees also provided an assortment of wild fruits along with the kernel of the palm nut, considered a delicacy. The trunks of the wine palms, true to their name, emitted a sap that could be fermented to make wine or boiled down to make sugar.

Further, by clearing forest in certain areas, the settlers were able to grow crops in gardens, farms and plantations. Now the Easter Islanders also had an assortment of starches and vegetables as staples in their diet. They had an abundance of food.

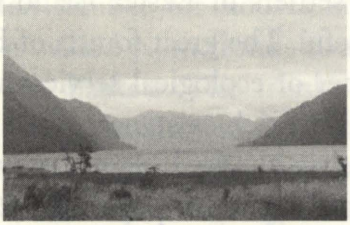
Through the hydrologic cycle the trees "attracted" rain onto the island to provide water for the crops. Since the crops were originally planted like a checkerboard among the trees, the trees were also able to protect the soil from erosion by rain or winds.

Not least, the trees also provided firewood for fires —for cooking their food, providing heat and lighting up the dark night. Yes, the settlers of Easter Island found their forests extremely useful. The great forests of Easter Island provided all manner of ecological services which allowed the islanders to live a rich existence.

In this fashion, after six hundred years of existence, the Easter Islanders reached a peak of population, abundance and ecological impact around 1500 AD, with a total population of roughly 15,000 and an expanding, but unsustainable, economy.

By 1500 AD deforestation was proceeding rapidly on the island. The booming economy was being powered by cutting trees at a rate higher than the trees could regenerate. In modern terms we would say that the islanders, to support the high level of their economy, were exploiting the ecology of their island *at a rate above its carrying capacity.*

In the terms of Meadows, Randers and Meadows, the Easter Islanders had entered into a phase of *overshoot.*



16. EASTER ISLAND III

As Jared Diamond points out, the person who cut the last tree on Easter Island probably thought nothing of it. After all, the clearing of the trees had proceeded gradually over generations, so that only real old-timers could remember when there were forests on the island. Now land for farming was everywhere to support the high population.

As the Easter Islanders lost their trees, they also lost the wild fruits and nuts that the trees had provided. With the loss of the trees the islanders also lost the ability to build harpoons and seagoing canoes, so they lost most of the seafood in their diet. The land birds, from unsustainable rates of hunting, went extinct. Seabirds were reduced to a remnant population. Thus the islanders lost most of their sources of wild food.

Meanwhile, their domestic food supply was also

being affected by the deforestation. As the forests disappeared, the soil of the island began to erode. Unprotected by trees, the soil blew away as dust and washed away in rain gullies. Further, the soil lost nutrients as the farmers no longer had a rich compost—decomposed fruit, leaves, twigs—to spread on the soil. And rain declined because there were no longer trees to attract it.

As the soil suffered nutrient loss and then increasingly blew or washed away, the food supply per capita began to decline. Near-simultaneous with this development, the economy of the island also began to decline. As fewer and fewer trees remained, the rate of harvested trees began to decline—and along with it, the economy, because the economy was still dependent upon exploiting the ecology at an unsustainable rate.

As economic activity lessened, the Easter Islanders became poor. Activity of all kinds decreased. As their soils declined in quality and washed away and blew away, the islanders began to starve. As they began to starve, their population also began to decrease.

This was a gradual process at first, like a train leaving a station. Then the decline in population gathered momentum. And finally, as food became more scarce and economic activity was collapsing, the islanders slipped from a highly organized society into chaos and civil war.

When the islanders started to realize that they were in an ecological catastrophe, at first they built larger stat-

ues with which to make more urgent appeals to ancestors. But then, as the island slipped into war and then anarchy, the statues were systematically destroyed by rival groups.

Later on, the islanders began making a different manner of stone statue—*moai kavakava*—small statues depicting a hollow-cheeked, starving people.

Finally, in desperation, the islanders turned to the last source of food available to them—cannibalism. Their records of that time indicate an obsession with it. Finally, even that didn't work (because it's self-limiting) and the population collapsed to a small remnant of people, who turned to living in caves for protection. This was the state of affairs when the Dutch explorer Jacob Roggeveen discovered the island on Easter day of 1722.

Then, in 1774, the English explorer Captain Cook visited Easter Island and saw its remaining inhabitants, whom he described as "small, lean, timid and miserable." And that was the end of the once-thriving Easter Island civilization. In technical terms, Easter Island had gone into what scientists call *overshoot followed by collapse.*

That state of overshoot is what Meadows, Randers and Meadows describe as the state of the earth today. Let's now take a closer look at that notion.



17. THE ECOLOGICAL FOOTPRINT

A researcher named Mathis Wackernagel and his colleagues asked themselves an interesting question: Could the total impact of humanity on the environment be measured, and if so, could that impact then be compared to the ecological carrying capacity of the planet?

They added up the various *sources* that humanity is heavily relying upon—minerals, forests, fisheries, fossil fuels, underground aquifers, fertile soils, fresh water, biodiversity, etc.—and the various *sinks* that humanity is relying upon to dump its wastes—the atmosphere, the oceans, landfills, etc., and also nature's extensive breakdown and recycling processes in the soil and elsewhere.

Anyway, they added up all of this reliance upon nature's resources and then gave it a name—humanity's *ecological footprint*—measured in earths, as in: How many earths are needed to support this ecological footprint?

And here's what they found: That until 1985 or so, humanity had an ecological footprint less than 1.0—less than one earth. However, in the mid-1980s humanity passed that mark and is now at 1.2. That is, humanity is consuming the resources of 1.2 earths.

In Meadows, Randers and Meadows' terms, the earth has *overshot* its carrying capacity by 20%. This is significant, because it's the first serious effort to measure, not just the effect of one area such as soils or climate or fresh water, etc.—but to assign a number, on a planetary level, to humanity's current footprint on our planet.

Overshoots are a common occurrence in everyday life. For instance, let's say we're drinking alcohol at a party. As alcohol enters the body the liver is constantly detoxifying this poison. However, beyond a certain point the body goes into overshoot, because it can no longer detoxify the alcohol as fast as it is entering the system. Next morning we describe the aftermath of such an overshoot, depending on how large it is, as "a hangover" or "a brutal hangover."

And that's part of the point: Once a system goes into overshoot, once that system has gone beyond the natural limits of the ecosystem which supports it, the system must somehow get back below the carrying capacity of its natural body—whether that body is a personal body with too much alcohol or the body of the earth itself with large declines in her biosphere.

Whatever the system, if it's to survive its ecological footprint must somehow get back below 1.0.

Once a system has gone into overshoot there are essentially only two ways in which it can get back below the ecological carrying capacity: Either with *oscillation,* or through *collapse.*

Overshoot and oscillation. This is the path where the human race takes prudent steps, and quickly, to bring itself back under earth's carrying capacity. This will still entail some pain, since both population growth and economic activity will have to be brought to a sustainable level. This will require enlightened leaders and an enlightened worldwide populace to help guide the planet through dampening oscillations to a sustainable future.

The other possibility, once a system has entered into overshoot, is *overshoot and collapse.* An example of this is the stock market in 1929. The market had been accelerating upward all through the 1920s and finally entered a parabolic phase after 1926 where prices just levitated to higher and higher levels.

By 1927 the stock market was in overshoot, yet kept climbing higher and higher on a wave of exceptionally easy credit. Because nothing was done by the government to stop the mania, it just soared higher (like the Dutch tulip mania two centuries before). Finally the overshoot broke to the downside, as inevitably it must, and the market fell relentlessly for three years, ultimate-

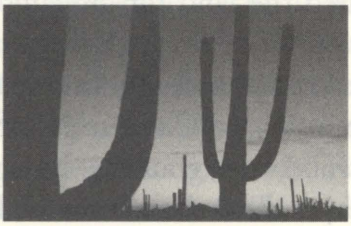
ly losing 90% of its value and ushering in The Great Depression.

That is what can happen when a system enters into serious overshoot and immediate steps are not taken to ease it back to a sustainable level. Then it must collapse, and it does so involuntarily.

The problem and challenge, of course, is that now we are not talking about the overshoot of a single system somewhere but of the entire planet. Needless to say, it's an unprecedented situation and humanity has entered uncharted waters.

The bottom line: Unless prudent steps are taken quite soon the planet will likely enter into a collapse stage sometime in the next few decades, where the processes of nature will bring humanity, *involuntarily,* down below the carrying capacity of the planet. But natural processes will do so through a drastic involuntary decline in the human population from starvation, economic collapse, wars, pandemics, resource scarcity and choking pollution.

We do still have a choice. Though we're in overshoot mode, we still have time, it seems to me, to enter a guided oscillation phase and avoid collapse. However, it seems likely that we must act quickly and with consummate skill and foresight. Farther on, we'll consider how such an outcome might look.



18. THE ANASAZI

A very interesting society that Jared Diamond talks about is the Anasazi peoples of the Southwestern United States, who existed from about 600 AD to about 1150 AD. They inhabited the huge Chaco Canyon of New Mexico and surrounding areas for about 50 miles out.

The Anasazi built hundreds of miles of roads and constructed the tallest buildings in pre-Columbian North America. They enjoyed a thriving civilization. So what happened? Why did they collapse?

The large Chaco Canyon inhabited by the Anazasi was filled with pinyon trees, a beautiful and hardy variety of tree that provided the Anasazi with a broad variety of services:

First, the living trees provided shade, beauty, rain and pinyon nuts. But the Anasazi discovered that, as useful as the trees were alive, they were even more valuable

when cut down. Then the trees provided lumber for buildings, they provided firewood for fires—and most of all, cutting the trees cleared the land for growing corn, the staple of their diet.

The civilization became so successful that gradually all the trees were gone in Chaco Canyon. No matter, because lumber and firewood, etc., could be brought in from the surrounding areas as the Anasazi extended their influence over wider regions.

Now the huge valley was used mostly for farming, and was able to grow the corn and beans that were the mainstay of the diet. Over time, though, with less and less tree cover, flooding became more frequent and the soil began to degrade. The soil not only lost nutrients but kept washing away through deep gullies formed in the denatured land.

So the Anasazi woke up one morning and made the discovery that they could no longer grow food in Chaco Canyon. No matter, because they could import their food—along with lumber, pottery, turquoise and everything else—from the surrounding areas, which they controlled.

The Anasazi reached their peak around 1050 to 1100 AD. However, their economy was unsustainable because it was being powered now by going further and further into overshoot.

That is, trees in the whole surrounding area were

now being cut at a rate faster than they could regenerate. The soil was blowing and washing away far faster than it could be regenerated. And it was losing nutrients. *The Anasazi reached a point where their economy was powered by a use of their ecology beyond its carrying capacity.*

Though Anasazi society was now in overshoot, it was not noticeable right away. That is one of the features of overshoot, that the effects don't normally show up right away. Rather, they show up after a delay.

For instance, if we've drunk too much alcohol in the evening, we don't normally notice it that evening. Instead, we notice the outcome, our hangover, *the next morning.* There's a delay between the overshoot and its ultimate effect.

Similarly, when the enormous banks of codfish were overfished off the Newfoundland coast, the effects were not seen right away. Though cod were being caught much faster than they could regenerate, the catch stayed steady for years while the overall stock was declining. But then, as overshoot continued, the Newfoundland cod fishery collapsed.

Something not dissimilar happened to the Anasazi. Ecologically, they were "living beyond their means," as it were, but the effects were not noticeable immediately because the economy continued to thrive. But internally their economy was becoming more fragile—dependent now upon a smaller and smaller base of woodlands and

fertile soil.

Then a series of droughts hit, beginning in 1029. In earlier years, when the population was smaller and its impact upon the environment was less, the Anasazi could have weathered the droughts.

But now, having overused their ecological resources for so long, they couldn't meet this challenge. According to archeologists, as the effects of the overshoot started becoming apparent, and food and other goods became more scarce, the Anasazi descended into a series of conflicts, wars and civil unrest—the normal process.

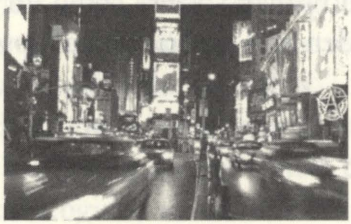
Now the Anasazi fought each other over increasingly scarce resources. Some were killed in various conflicts; others starved. And the Anasazi civilization ceased to exist.

That is the danger of overshoot: If not managed wisely so that the society is skillfully (and fairly quickly) brought down below the carrying capacity of its ecology, then the overshoot reaches a point where the society can no longer avoid a serious decline, which can arrive quite suddenly and precipitously.

That is the current challenge to the human race. We are already in planetary overshoot by roughly 20%, according to scientists, and in spite of various efforts humanity is steadily increasing its ecological footprint on the earth.

The result could be similar to other examples in our

history, only on a much larger scale. If we cannot find a way to fairly rapidly bring ourselves under the carrying capacity of the earth then human society could, in just a few decades, suffer a sudden and surprising collapse.



19. EXPONENTIAL GROWTH

There are three components that are integral to the condition of overshoot:

1. Exponential growth of something;
2. Existence of limits to that growth;
3. Signal delays about those limits.

Let's take them in turn:

1. Exponential growth

There's a big difference between *linear*, arithmetic growth and *exponential*, compounding growth.

An example of linear growth would be if we put $1,000 in a bank and the bank promised to add $100 to the account each year. In that case the account would be

growing linearly at $100 per year—it's growing by the same amount each year.

However, if the bank promised to pay 10% annual interest on the account, now it would be *compounding*. Once it's doing that, it's growing at an *exponential* rate.

What's the difference? In the first year the compounding account would add $100, for a total of $1,100, same as the linear account. But in the second year the 10% would be applied to the new total of $1,100, so that $110 would now be added. And in the third year the 10% would be applied to the new total of $1,210, so that $121 would be added this time, and so on. The whole point of exponential growth is that *the new parts are also growing* and compounding.

Continued over 50 years, the linear account would be worth roughly $6,000—the original $1K plus $5K interest. However, the compounding account would be worth $117,000. Quite a difference!

The human population on earth has been growing at an exponential rate for a long time now. About 11,000 years ago, during the Agricultural Revolution, there were about 10 million humans on the earth. By 1650, at the dawn of the Industrial Revolution, the human population was about 500 million humans—a compounding growth rate of 0.3% per year.

By 1900 the human population had reached a level of 1.6 billion, a growth rate of 0.7% per year. By 1965 the

population had reached 3.3 billion and was growing at 2% per year. Now, in 2007, the human population is about 6.5 billion people and the growth rate is 1.3%. Yes, the growth rate is slowing, but the human population is still very likely to go up for decades. Here's why:

Even if the human reproductive rate slowed immediately to 2.1 children per couple (the replacement rate), the human population would still keep growing for another 50 years and would add another 2 billion people or so—because there are many more young people than older people on the planet now, which means that more reproduction is going on and will be going on for awhile.

As mentioned above, this phenomenon will keep driving the human population upward for decades even if the average reproductive rate of 2.1 children per couple were somehow magically achieved today. In turn, that means that the planet will somehow have to sustain a human population of 8 to 9 billion people by 2050.

The planet is already in overshoot some 20% with 6.5 billion people. Two billion more people will tend to add about 30% more demands upon the earth's ecological resources and carrying capacity. And there's more:

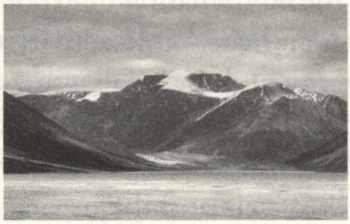
With ups and downs, human economic activity has also been growing at exponential rates since the beginnings of the Industrial Revolution around 1750 AD. But since 1960 economic activity has accelerated even more, with global economic activity now growing at about 3%

per year, which means it doubles every 24 years.

This places an added burden upon the earth's ecological systems—because the combination of exponential growth in both population and economic activity drives exponential growth in energy and materials use as well. In addition, growth in population and economic activity drives exponential growth of wastes and pollution—into the atmosphere, the soil, the rivers and the oceans.

The concept of growth has now become enshrined among the public, governments and the media. It is held to be self-evident that only growth and more growth can solve all problems. Only through growth, it is said, can humanity gain enough wealth to afford new technology, ameliorate poverty, and not least, combat the worsening ecological situation. Individuals, politicians and business leaders all worship at the altar of growth.

Yet as we have seen in our historic examples (and many others could have been used), exponential growth in a finite system is bound eventually to create more problems than it solves, because it drives the society into greater and greater overshoot, which then degrades and undermines the ecological foundation upon which all human population and economic activity ultimately depend.



20. GROWTH LIMITS I

2. Limits to that growth

This is the second factor in the conditions that contribute to the phenomenon of overshoot.

Imagine that we've got a car and we drive the car fast enough that its engine rpm gauge goes over the red-line and stays there for awhile as we're driving. Notice that though we're "pushing" the engine beyond its limits that the engine keeps running—for awhile.

However, an engine being run continuously above its rpm redline *is steadily and rapidly deteriorating.* Above its redline, the engine is literally wearing itself out at a rapid rate. Yet we notice the engine does keep running—until it reaches a point where it suddenly breaks down.

Not to be overly dramatic about it, but that is not a bad metaphor for where our planet is at the moment. In

essence the planet is "running" at a pace 20% over its redline. And yes, it's still running, like the car engine, but that doesn't mean it will do so forever.

Indeed, the best computer models show the planet, if current trends continue, probably going into "collapse" mode within a few decades. We could argue that that notion is preposterous—but what if it isn't? Are we prepared to take that risk?

It's not that the earth will suddenly run out of minerals, fossil fuels, fresh water, fertile soils, etc., but that the cost of getting and using these things will keep going up and that the increasing cost will—sooner rather than later, according to these models—eventually reach a point where it can't be sustained. And according to the models, it's at that point that industrial production, food supply and population are all in danger of collapsing.

To make this notion more concrete, let's look at an example. In Butte, Montana there is a copper mine. Over the years the percentage of copper in the ore has gone from 30% to 0.5%. As a result of this, the waste produced per ton of metal has gone from 3 tons to 200 tons.

Or, to put it another way, at that mine they now have to process 200 tons of rock ore, instead of 3, to obtain that 1 ton of copper—a 67-fold increase. That means 67 times as much rock must be processed, using 67 times as much energy.

The copper has not run out, no. It's just that it has

become a lot more *expensive*—in terms of energy, capital and waste—to obtain and use.

In fact, the price of copper has increased dramatically in recent years, reflecting this story told worldwide. The prices of raw materials of all kinds have been rising, and for essentially the same reason. So also with non-renewable energy resources such as oil and natural gas.

It's not that humanity is running out of oil right now, for instance. Rather, it's that we are having to look for oil in more remote, more inaccessible, more challenging environments, and this is taking a lot more energy and industrial capital for each barrel of oil obtained.

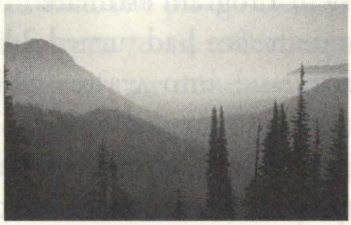
Moreover, the productivity of existing oil fields is declining as more and more oil is pumped out. Combine that with the fact that the rate of discovery of new fields has declined dramatically since the 1960s, and it's not difficult to see why the price of oil (particularly in terms of the falling dollar) has skyrocketed in the last few years as the marginal cost of producing it has gone up.

All of this is another way of saying that we're reaching limits in raw materials of various kinds. It's not that we are running out of them, exactly, but that the expense and energy to obtain them is steadily increasing. Should we continue on our current course, then, within a few decades we might find that a good deal less energy and capital are available for other sectors of the economy such as food, infrastructure and services.

The same thing is happening with soil, yet another limit that humanity is running up against. In 1986 the United Nations Environment Program estimated that in the last 1,000 years the human race had turned 2 billion hectares of productive farmland into waste, which is more than the total amount being farmed today.

Fertile land is being lost from four main causes: soil erosion, loss of soil fertility, salinization of soil and desertification. Indeed, one-third of all the land in the world is now desert, and that area is increasing. Globally, the amount of arable land available per person has declined from 0.6 hectare in 1950 to 0.25 hectare today.

Through intensive farming methods the amount of food grown worldwide has increased since 1985, yet the amount of food grown *per person* has been steadily falling since then (because of the rise in population). In addition, the humus in the soil is being lost at an increasing rate: an average of 25 million tons per year up to the year 1750, an average of 300 million tons lost per year from 1750 to 1950, and since 1950 an average of 760 million tons of soil humus lost per year.



21. GROWTH LIMITS II

Yet another kind of limit that humans are running into is the amount of fresh water available. Only 3% of the water on the planet is fresh water, and that is being increasingly compromised. Vast groundwater aquifers are being depleted and polluted at an accelerating rate, and 75% of the world's major rivers are now severely compromised. Mountain glaciers, which provide water to 1/3 of the world's population, are melting.

All through the 20th century rates of fresh water use have climbed twice as fast as population growth, and that trend is continuing today. The availability of fresh water affects *everything* else, from farming to mining to industrial production, and humanity is currently in severe overshoot in its use of water.

Another kind of limit is taking place in the world's forests. Originally there were about 6.5 billion hectares of

forest on the planet. Approximately 3.9 hectares remain —and that figure counts a lot of marginal "forests" that have been overlogged, clear-cut, burned or regrown with much smaller second-growth trees.

Of earth's original old-growth forest, only 1.3 billion hectares—20%—remain. Of the original forest, 95% has been cut in the United States and a similar percentage in Europe. Of China's original forest, 75% is gone and so on. Currently, most of the global forest losses are occurring in the world's rainforests.

Over 50% of this loss of natural forest has occurred just since 1950. Pressure on the forests is coming from intensive logging, mining, corrupt officials, growth of cities, clearcutting for agriculture and other sources. And of course this loss of forest directly affects soil fertility, soil erosion and desertification.

Another kind of limit is occurring in the various animal and plant species that exist on earth. Biologists are certain that a mass extinction of species is occurring on our planet, but it is difficult to quantify. To date about 1.5 million species have been discovered and classified by science, yet it is estimated that roughly ten times that many species exist.

One interesting approach to quantifying the phenomenon of species extinction has been an ongoing study undertaken by the World Wildlife Fund. In this study the decline in a large number of individual species of all

types are tracked and then averaged together to come up with an "average" species decline. By this reckoning the "average" species on planet earth has declined about 37% since 1970.

Think about that: a 37% decline in the average species just since 1970! Estimates are that species decline and extinction on planet earth are occurring at a rate roughly *1,000 times* the rate that would be occurring without human impact.

Well, so what? we might say. So what if some frog goes extinct over here or some plant goes extinct over there or some insect goes extinct somewhere. How does that affect *my* life?

The various species on earth are mostly unheralded, but they perform countless *ecological services,* as the term goes. Just a few examples out of many are the detoxification, purification and recycling of air and water; regeneration of soil nutrients and soil structure; pollination and seed dispersal; and immeasurable spiritual and aesthetic uplift.

The thing is, it's all connected. It's not just this species or that species, because it forms a vast interconnected ecological web where predator and prey are connected, where breakdown and buildup are connected, where the waste products of one process become the inputs to another natural process in a web of incalculable complexity.

As Meadows, Randers and Meadows point out, the species extinction on planet earth has been compared to flying in an airplane where the rivets that hold the plane together are popping out one by one. How many rivets can we lose before the plane comes apart? *No one knows.*

One more kind of limit is the finite ability of planet earth to absorb, detoxify, purify or sequester various types of pollution. It's true that good progress has been made in the industrialized countries in lowering the levels of specific toxins such as lead, DDT, cesium-137 and sulfur dioxide. However, in the developing countries the situation—even with these "success stories"—is not promising.

The larger situation is that the earth is receiving more toxic chemicals and pollution than she can handle. Among other overshoots, the earth is in toxic material overshoot. Three quick examples:

First, the world is now producing almost 65,000 industrial chemicals found in standard commercial use. Virtually all of these new industrial chemicals have never before existed on the earth, so nature has evolved no way to detoxify them. They range from pesticide and nitrate contamination of the soil to PCB pollution of rivers and groundwaters to mercury, cadmium and other heavy-metal pollution in coasts, fish and shellfish.

A second example is the tremendous production of nuclear wastes in the world. Like industrial chemicals,

these wastes have never existed on the earth before and so nature has evolved no method of detoxifying them. They break down only at their own pace, which can be decades, centuries or even millennia.

A third example of toxic overload or overshoot of the planet's sinks is the build-up of greenhouse gases, discussed earlier. Suffice it to say that the exponentially growing levels of CO2 and methane in the atmosphere have not been seen for the last 160,000 years at least, long before the advent of civilization.

Signs are appearing all over the globe, from ocean acidification to species extinction to deforestation to soil degradation, that the earth's pollution sinks are under great stress and in a state of overshoot.

We can sum up this discussion of global limits with something that Mathis Wackernagel and colleagues have said, based on their extensive calculations: "To accommodate sustainably the anticipated increase in population and economic output over the next four decades," they said, "we would need six to twelve additional planets."



22. DELAYS & THE MAYANS

3. Signal delays

This is the third factor in the conditions that contribute to the phenomenon of overshoot.

When a system is in overshoot and thus existing beyond its functional limits, the environment which supports that system begins sending distress signals back to the system.

These feedback signals can be delayed or distorted, dismissed or ignored. Even if they are acknowledged, the resulting action to counteract the overshoot may be delayed or inappropriate.

In the case of the human ecological overshoot, for instance, the planet is signaling us about it in various ways ranging from the melting of glaciers to the collapse of fisheries to increasing desertification. All of these are

"signals" from the earth to the human "system" that it is in serious overshoot.

But the signals are not necessarily being received or acted upon. In many capitals of the world the true situation is not fully recognized. Examples are Washington, Delhi and Beijing, among others, where the overshoot of the earth's carrying capacity is still largely dismissed.

Political leadership can make a huge difference, one way or another:

As it was stated in *Limits to Growth,* "Overshoot comes from *delays in feedback.* Decision makers in the system do not immediately get, or believe, or act upon, the information that limits have been exceeded."

For example, the Classic Mayan civilization from roughly 250 AD to about 900 AD, went through a typical cycle in what is now Honduras and the Yucatan Peninsula of Mexico. First the valley floodplains were settled. Abundant trees in the valleys were available and cut down for firewood and to make way for farming,

Conditions were good, and the population grew. And as the population grew, more and more trees in the valley were cleared until the valleys were almost all farmland. And still the population kept growing.

No problem. About 650 AD, the Mayans expanded up into the hills above the valleys and cut down the trees there as well for firewood and farming. Population kept increasing and reached at least 5 million people. But

the Mayans had now entered into overshoot.

The problem was that as the forests in the hills were cut down, the forests no longer provided cover to the soil and so the hills lost soil nutrients and soil itself, washing down the hill with periodic rains. But this situation was ignored as long as there were more trees to clear on the hillsides—and so the population kept on increasing. In modern terms, the Mayans were now in serious overshoot and ignoring it.

The Classic Mayan civilization was once thought to be a time of peace and gentleness. Archeologists now know that it was a time of chronic warfare among rival Mayan kingdoms. Relentless self-enrichment aside, the Mayan kings were mostly preoccupied with making war among each other. The wars intensified around 750 AD when the hills had to be abandoned and people flooded down into the valleys just as arable land was becoming more scarce.

Thus preoccupied with their internecine struggles, Mayan leaders didn't recognize the signs of their increasing ecological deterioration and did not act upon those increasing warning signs.

Then three severe droughts hit, in the years around 810, 860 and 910. The Mayans had successfully withstood draughts previously, but that was back when their population was smaller and their soils and forests were still abundant. This time, with a greater population, poor

soils and the effects of deforestation, they couldn't cope.

Thus, at the height of its population and power, the Mayan civilization, the most advanced in pre-Columbian times, went from severe overshoot into what is now known as the Classic Mayan Collapse. In the southern lowlands, 99% of the population vanished over time from internecine warfare and starvation.

By the time of the Spanish arrival in the 16th century, the land was virtually devoid of people and the great Mayan temples and monuments had become all but invisible, overgrown with forest vegetation and not to be discovered again until 1839.



23. MEDIEVAL JAPAN I

A similar story, though with an interesting twist, occurred in medieval Japan. Immigrants came over from Korea and China from the 3rd century BC onward. And vast forests were everywhere. The new inhabitants, of course, set about clearing areas of forest for farming, housing and firewood.

As time went on, clearing of forests continued, but the forests were still so vast that nobody gave it much thought. Then, around 1600 AD, with the advent of the Tokugawa Shogunate, the country entered a period of unusual prosperity. During that century, from 1600 to roughly 1700, the country accelerated upward in both population and economic activity.

To support this wave of prosperity, more trees were cut than ever. So many that sometime around 1650 the society went into overshoot, and by 1700 it was in seri-

ous overshoot, because its racing economy was dependent on an ecology that was rapidly dying.

In fact, according to archeologists, by 1710 the main areas of Japan, except for some remote places, had been deforested. And because of that, the soil and its nutrients had been eroding more and more. Sure enough, by the late 1600s a series of famines was occurring across the land.

But then a remarkable thing happened: Everybody kind of woke up about what was happening, led by farsighted political leadership. The wake-up had begun back in the 1660s when the shogun Tokugawa Iatsuna had warned, according to Jared Diamond, "of the dangers of erosion, stream siltation and flooding caused by deforestation."

Though efforts at forest management began around 1670, at first they were small and mostly ineffectual. Yet under the shogun Tokugawa Tsunayorshi, from 1680 to 1709, these efforts accelerated. Then, under the reformist shogun Tokugawa Yoshimune, governing from 1716 to 1745, the national effort to save the forests of Japan really took off.

The effort was spearheaded by returning to the country's mythic roots in Confucianism, stressing "social harmony" and a benevolent approach towards nature. To achieve such harmony, the reformist shoguns grasped, would require nothing less than a sustainable society—

sustainable in all three areas of forests, population and economic activity.

Because the gravity of the developing crisis was recognized, everything possible was done. First, a series of "negative" measures were taken in order to drastically slow the cutting of trees. They included banning the practice of clearing forests, closing off forested lands to permit regeneration and tightly regulating who could log on the land and by how much.

Measures also extended to living style, such as incentives for lighter house construction, mandating building styles that could take advantage of solar heat, encouraging fuel-efficient small portable heaters and cooking stoves instead of large fireplaces and so on.

The effort was extremely sophisticated, and as Jared Diamond points out, these first measures "bought time, prevented the situation from getting worse until positive measures could take effect, and set ground rules for the competition within Japanese society over increasingly scarce forest products."



24. MEDIEVAL JAPAN II

Next came "positive" measures to encourage the regrowth of forests. Stimulated by the shoguns of this period, there was an outpouring of studies and books about *silvaculture,* that is, the practice of growing and maintaining forests. Very gradually, Tokugawa-era Japan began to grasp the concept of *plantation forestry,* where forests are perceived as a symbiotic, slow-growing crop.

Plantation forests have relatively large initial capital costs. And of course, a long-term perspective is required. However, if well-managed, they can provide a sustainable supply of forest products to a society as well as conferring several important economic advantages:

1) Preferred species can be planted; 2) quality can be maximized; and 3) locations can be made convenient to rivers or cities for lower transportation costs.

As Japanese society came to comprehend the vital

importance of plantation forests to their lifestyle and economy, and as a series of shoguns created incentives for those forests, they sprang up everywhere and became widespread in the period from 1750 to 1800. By 1800, to its immense benefit, Tokugawa-era Japan had ended its long decline in timber and had essentially succeeded in stabilizing its relationship with its forests.

The reform shogun Tokugawa Yoshimune and his successors emphasized as well that the *population* would have to stabilize. They were intelligent enough to understand that to reach a truly stable society it was not enough to stabilize the forests. The society must also reach a stable state in population, they realized, so that the pressure on the ecosystem could decline, and remain, below the ecosystem's carrying capacity.

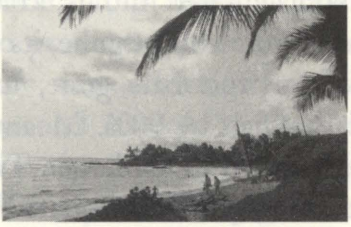
Consequently, a number of practical measures were implemented: Couples were encouraged to marry later, mothers were encouraged to nurse their babies for longer periods—thus spacing out pregnancies—and contraception became widely available and practiced.

Underlying these measures was the resurgence in Confucianism, encouraged by the shoguns, which emphasized order, balance and harmony. The whole society came to understand that it was desirable to bring the population to a state of stability—and remarkably, in the century from 1721 to 1828 the population of Japan remained stable at 27 million people.

The third pillar in Japan's recovery from the brink of disaster was the stabilization of its economy. This was primarily accomplished through a society-wide introspection about the Confucian ideals of moderation and prudence. Excessive consumption was discouraged and seen as not being conducive to happiness. Reserves were put aside to protect the country against disaster. The society stabilized and preserved itself, due in no small measure to far-sighted political leadership.

Japan has maintained its remarkable perspective on its forests to the present day. Indeed, of all developed countries Japan has by far the greatest percentage of forest. All of Japan's cities and agriculture are situated on just 20% of its land. *Almost 80%* is dedicated to the forests, and the Japanese people often proudly refer to their country as "the green archipelago." Among other advantages, this assures Japan of plentiful rainfall.

(As a coda and counterpoint to this encouraging story, however, it must also be mentioned that Japan, along with Norway and Iceland, for many years has been especially rapacious in the hunting of whales, helping to cause a precipitous decline in many whale species.)



25. THE ISLAND OF TIKOPIA

Another interesting example of sustainability is the island of Tikopia in the South Pacific. It's almost as isolated as Easter Island and quite a bit smaller. Yet, unlike the grim fate of Easter Island, Tikopia has managed to exist sustainably for almost 3,000 years.

According to archeologists, Tikopia was first settled around 900 BC by ancestors of modern-day Polynesians. The island was so isolated that there was no question of importing food or essential materials; this isolated island, like Easter Island, would have to live or die on its own.

At first the inhabitants partook of the fruits and nuts offered by the trees. And the islanders gorged themselves on plentiful seafood found all around—fish, shellfish, turtles and all sorts of birds to be had for the taking. Of course, forests were cleared for farming, firewood and

lumber. And of course, too, in this abundant situation the population kept growing.

Around 100 BC Tikopia entered into its ecological crisis. By then its rainforests were almost gone, its major bird species extinguished, its fruit bats gone, its fish down by two-thirds and shellfish by 90%. Meanwhile, the human population had grown much larger. Tikopia had entered into a severe overshoot. Now what? Would it suffer the same fate as Easter Island?

No, it wouldn't. Wise measures were undertaken in time to deal with the crisis. Then, experientially over the next thousand years, the Tikopians gradually discovered what would work best and evolved into a fully sustainable society, a form of medieval permaculture.

If we had visited Tikopia around 1000 AD we'd have found it to be very similar to what it is today. Essentially, the island has been turned into one giant orchard with various fruit, nut and palm trees including breadfruit, coconuts and almonds. Interspersed among the trees—the lower level of the orchard, so to speak—are farms and gardens where bananas, yams, taro and other foods are grown.

The last major change occurred around 1600 AD. The Tikopians were raising pigs as a food staple in their diet; however, since the pigs were also competing with humans for food the island had, bit by bit, slipped into another ecological crisis.

Eventually it was realized that livestock could not really be part of a stable situation because of a simple equation: It took about 10 pounds of fruits and vegetables to produce 1 pound of pork, so once again a food shortage was occurring. The Tikopians took the drastic step, around 1600 AD, of killing all the livestock on the island so that they could reach sustainability.

To replace the pigs in the diet, the Tikopians turned once again to fish, shellfish and turtles, whose numbers over the centuries had gradually rebuilt somewhat. But this time the islanders did it differently. Their chiefs issued permits, in effect, which limited how much seafood could be caught at any one time. Through this permit system the Tikopians addressed the challenge of maintaining a sustainable seafood source.

The Tikopians over time were also wise enough to realize that they would have to limit their population if they were to reach sustainability. A number of methods were used, such as celibacy, contraception and abortion, to limit the number of births. But these were just the outward means; the real transformation took place inwardly, in how the islanders thought about the sustainability of their island.

Each year on Tikopia the chiefs hold a ritual in which they once again preach about the merits of *zero population growth* for Tikopia. Because of this and other educational efforts, all residents of the island share a keen

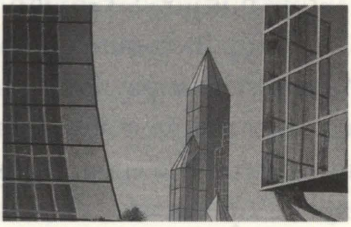
awareness that population must be held within limits if the island is to survive. And they act accordingly, through practicing birth control and limiting the number of children in each family to replacement level.

In effect, the Tikopians succeeded in creating their form of a permaculture, mentioned earlier. In doing so, they designed their agriculture and culture to be part of the biodiversity of nature.

On Tikopia, fruit trees and fruit bushes and crop lands were intermingled, creating biodiverse areas where humans could live sustainably and with minimal energy input. In other words, their permaculture did not require the massive injections of fossil fuels that our monoculture agriculture currently requires.

We could learn from the Tikopians about this. By adding modern permaculture designs, which consciously incorporate the interlocking patterns of nature, we could create a 21st-century version of their achievement.

But the real insight to their long-term sustainability resides even deeper than that. It resides in their sense of who they are. Tikopians commonly refer to themselves as "we, the Tikopia." That is, they conceive of themselves as *one people,* and all of their actions are considered in that light. How will each of our actions affect our island as a whole? Hmm. Not so bad a metaphor for us humans on planet earth.



26. ADDICTION TO GROWTH

Imagine that we're the captain of a vary large ship which is traveling across a vast ocean. It's wintertime and there are potential icebergs up ahead. Moreover, the ship is traveling at night, so our ability to see way ahead in the distance is limited at best.

Under these circumstances, would you *increase* the velocity of the ship or would you *decrease* it?

Increasing the velocity of the ship in such circumstances would be reckless indeed, because the faster our large ship is going the less likely we would be to perceive an iceberg—or, to use different wording, a limit of some kind—in time.

Under such circumstances the first thing we'd want to do is *decrease* our speed, so that a catastrophe would be less likely and so that the situation could be assessed with as much intelligence and foresight as possible.

World economic activity is now increasing at approximately 3% a year. Almost everyone will tell you that this is a good thing. Growth is good. Growth is our religion, since we humans worship it so much.

But without growth, how can we pay for ecological clean-up? Without growth, how can we relieve poverty? Without growth, how can we keep the economy going? Without growth, are we not at a point where the economy could tip over into *negative* growth?

It's taken for granted that growth is a good thing. As Meadows, Randers and Meadows point out, we even have other names for it—*progress, advancement* and so on.

However, here's the thing: Growth at 3% a year doubles every 24 years. Under our present course, that means, by the year 2055, *quadrupling* our use of energy, *quadrupling* our use of material resources and *quadrupling* our output of waste into the environment.

It's not difficult to see that such growth cannot continue very much longer. We're already in 20% overshoot and the amount is increasing every year. An accelerating human economy, though it sounds at first like a good thing, actually leads to an increasing overshoot. As a system goes into overshoot it becomes increasingly likely to suffer a collapse. And the greater the overshoot the greater is the likelihood that the collapse will be of historic proportions.

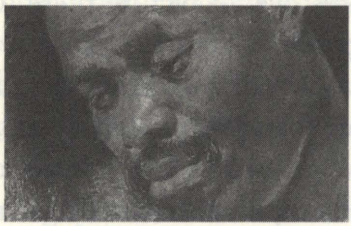
Somehow, if we're to survive, we'll need to get used

to the idea of a sustainable planet, where population and the general level of economic activity remains stable.

Of course, within this overall picture there will be individual areas of change. For instance, almost by definition, for the poor of the world to increase their living standards will require some growth. Consequently, on a sustainable planet this would mean that the developed countries, as a counterbalance, would actually be implementing a slow and steady decline in their economic activity for awhile.

It's difficult to imagine that the developed world would voluntarily enter into a period of declining economic activity so that the developing world—the 45% of the world's population living on $2 a day or less—could improve their living standards within an overall picture of steady-state global economic activity. Yes, difficult to imagine, but it will likely be necessary in order to reach a sustainable planet.

Let's next look at an example that—if we do not take our increasing growth into account—could become an increasing metaphor for mother earth.



27. THE TRAGEDY OF RWANDA I

In 1994, only some 13 years ago, a brutal massacre occurred in Rwanda. About 800,000 Tutsis, about 11% of the population, were slaughtered, mostly by Hutus, the other tribal group in the country.

This massacre is usually attributed to ethnic hatred, of Tutsi for Hutu and vice-versa, fanned into flame by cynical political leaders for gains in political power. And indeed, that is the *proximate* cause. But for an *ultimate* cause, we'll have to look deeper.

In his visits to Rwanda, Jared Diamond was always struck, first off, by the high density of population. He says this: "To read in the abstract about 'the population explosion' is one thing; it is quite another thing to encounter, day after day, lines of African children along the roadside."

Rwanda's population had been growing since the

19th century, helped along by adequate rainfall, improved hygiene and preventive medicine, and the introduction of more productive crops such as corn, beans and sweet potatoes.

Then in 1962, with Rwandan independence from Belgium and increased foreign investment, the population began to grow even faster, at a 3% rate per year. As we've seen, though a 3% growth rate may not seem like much, it doubles in only 24 years and quadruples in 48 years. That happened in Rwanda.

So by 1990 Rwanda's population density was 760 people per square mile, the highest in Africa and one of the highest in the world. True, a few other countries in the world had population densities at that level—Holland and the United Kingdom, for example—but those countries practice a mechanized agriculture that requires far less land to feed the population. This means that more land is available for preserving, to some extent, the natural ecology.

But in Rwanda such ecological devastation became commonplace. Methods of farming remained basically unchanged from olden times, based on hand tools such as the hoe and the machete. The growing population was accommodated by simply clearing more forest and draining more swamps to create farmland.

Meanwhile, even simple measures to protect the soil, such as terracing to prevent washouts or giving the

land a cover between crops, were not taken. As more and more trees were cut to create farmland, and animals overgrazed on grassland, the land eroded more and more. As Diamond tells us, "By 1985, all arable land outside of national parks was being cultivated,..Steep hills were being farmed right up to their crests."

About the same time, ecologists who studied the situation sensed that a disaster was looming. The land had become basically denuded and dry. It became more and more difficult to grow crops. By the late 1980s large famines were becoming prevalent.

Land disputes became endemic. It's estimated that by 1990 some 44% of all disputes in court were directly about land. Indirectly, probably most of them were.

Violence showed up more and more as the population became more stressed. Studies showed a remarkable finding—that the level of violence in different areas of Rwanda was directly correlated to population density and caloric sufficiency.

Now you know I can't resist a good generalization, so here goes—hopefully it's not too excessive. Anyway, I'd put the findings of those studies this way:

If a population is under great stress,
then in general,
the higher the population density
the higher the general level of violence.



28. THE TRAGEDY OF RWANDA II

Eventually, in 1994, the powder keg in Rwanda exploded. Urged on by cynical political leadership, the increasing violence of all types first molted into a civil war between Hutus and Tutsis and then devolved into a massive slaughter where approximately 800,000 Tutsis were hunted down and killed.

A horrific example, we might say, but what does that have to do with the earth as a whole? After all, Rwanda's soil was mostly denuded and drought-ridden, and that's not the case with the earth. Moreover, Rwanda had a history of ethnic violence which makes it something of a special case.

All true. But the similarities in the comparison might be more important than the differences. And the basic similarity, to me, is this: Rwanda was in ecological overshoot and so is the earth. Yes, there are differences,

and yes, Rwanda was in greater ecological overshoot than the earth now is. However:

–The earth's ecological overshoot rises each year.
–The earth is in an epidemic of deforestation.
–The earth is suffering huge overall soil erosion.
–The earth is becoming much warmer and drier.
–The earth is losing its vast underground aquifers.
–The earth is now 1/3 desert; desertification rises.
–The human race has a history of violence.

If these trends were to continue, the planet could, down the road, find itself in a situation not totally dissimilar to Rwanda's.

There appears to be a general societal progression that often happens:

1. A society goes into ecological overshoot.

All goes on pretty much as before; nothing much changes for awhile.

2. The society goes into more severe overshoot.

Signals of ecological, and eventually economic, stress show up. These signals are either ignored or they are acted upon.

If the signals are acted upon fairly promptly:

3a. The society moves increasingly in the direction of sustainability.

If signals are mostly ignored and/or effective action is mostly delayed:

3b. Chaos, violence, breakdown increasingly show up.

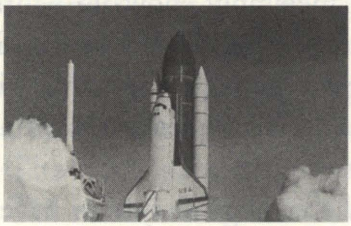
What seems clear is this:

When a society moves into ecological overshoot, stresses of various kinds inevitably show up—forms of ecological, economic and/or geopolitical instability. If those stresses become great enough they will without doubt resolve at some point. The question is what that resolution will look like.

If the stresses on the ecological system have been resolved through intelligent foresight and action, as in Tikopia and Tokugawa-era Japan, the situation can look enormously promising. It means that the overall state of things is going towards sustainability.

But if the stresses on the system are not resolved in time by far-sighted human action they will resolve on their own, guided by natural biological processes. And that latter type of resolution will likely appear indifferent to human welfare.

Back to our metaphor of the ship on the ocean: The greater the velocity and momentum of the ship, the more important it becomes to look as far ahead as possible—or to put it another way, the more important it becomes to consider the situation and act upon it from a long-term, rather than a short-term, timeframe.



29. THE EFFECT OF TECHNOLOGY

It's sometimes proposed that technology and free markets will solve any ecological problems, perhaps with a bit of tinkering here and there. The current U.S. administration, among others, seems to have great faith in this concept. Advanced technology, along with free markets, will bring about a solution without the need for slowing growth. The logic goes something like this:

A non-renewable resource, for instance, becomes more scarce, or more accurately, it becomes more and more costly to extract and refine. As this happens, of course, the price of the resource goes up. As the price goes up, more and more capital is allocated to achieving technological fixes to the problem, from finding more of the resource to extracting it more efficiently to finding alternatives to the resource.

Thus, through free markets and technology,

increasing scarcity brings about higher prices which brings about more intense technological and economic solutions which solve the problem. Voila!

But does it really work that way? Guided by *The Limits to Growth,* let's look at a real-world example:

The world's marine fisheries have seemed like an inexhaustible resource for most of humanity's existence. But as population grew, technology served the increased demand for fish, for example through refrigerated boats that could stay at sea longer. And as demand grew the fishing fleets grew much larger.

In recent years the technology has "improved" so much that fish are now caught in unbelievably large amounts. Radar and sonar have enabled boats to zoom in on schools of fish with unerring accuracy. Drift nets as much as 30 miles long, along with other technologies, have increased the catch tremendously.

As a result, most of the world's species of fish have gone into steep decline. To take just two examples, the worldwide population of bluefin tuna has declined by 94% in the last 30 years and that of the popular sturgeon has declined by 95% in the same timeframe.

Such precipitous declines have, predictably, greatly increased the prices of tuna, sturgeon and other fish. However, these higher prices have made these fish and others *even more desirable* from the point of view of business. So the efforts to hunt these fish have *intensified*—

in a vicious cycle where higher prices lead to increased fishing efforts, and more advanced technology is brought to bear in doing so.

The result is that the globe's overall population of fish is in staggering decline, with a number of species near extinction. According to the UN Food and Agricultural Organization, fully 75% of the world's marine wildlife is threatened. This astonishing phenomenon is a part of what biologists are calling The Sixth Great Extinction of life on planet earth.

Notice that in this free market situation, as greater effort and technology were brought to bear, overfishing greatly worsened. The reason for this is that *technology and markets serve the goals that are set for them.* If society's goal is growth, then markets and technology will serve and promote that goal—even unto extinction.



30. THE NATURE OF MARKETS

A study of history would generally dispose one to favor free markets. The history of centrally planned economies is generally a dismal one. Free markets tend to allocate investment capital with great efficiency, thus being powerful generators of societal abundance.

However, free markets cannot operate without restraint; they must be regulated to some extent. For example, pet poisonings have occurred recently from tainted food additives imported from China. Factories making food in China are unregulated and thus have an incentive, as in this case, to add cheaper "protein" from petroleum instead of actual protein into their products. Free markets are powerful and helpful, but they must have an overseer.

There is a sweet spot, a happy medium where business, industry and markets are generally free and yet are

operating within some appropriate constraints. These constraints on free markets—particularly in the context of a sustainable planet—are needed for three primary reasons:

1. Markets are not, per se, interested in society's "good."

Money, capital, tends to be amoral. Not immoral, actually, just amoral. For the most part, capital simply seeks the highest returns it can obtain consistent with minimizing risk. It's not usually interested in much else. Any investor is familiar with this goal—in a certain sense it's just the rational thing to do. In itself this is neither right nor wrong; it simply is the way that capital works.

However, this means that very cold calculation is sometimes employed. An hypothetical example from a Japanese journalist: If capital can obtain a 15% annual return for ten years by fishing a species to extinction, and a 10% annual return by fishing sustainably, it will often choose the 15% return over the 10% return, fish the species to extinction, and then seek some other species to hunt. From that point of view, it's just business.

2. Markets are inherently short-term creatures.

For example, there are all sorts of factors that could affect the price of oil ten years from now, but the global markets in oil don't care about any of that. The world-wide price of oil at any given time is determined by the

marginal supply and demand for oil at that time.

Since markets do not look long-term, if a society is to maintain itself sustainably then its markets must be placed in a long-term context. For example, a substantial carbon tax applied throughout the economy would tend to automatically incorporate a long-term perspective on the climate and the ecology into the oil markets and other energy markets, even though they're still operating freely—and short-term—within the longer-term context of that tax.

3. Markets don't consider "externalities" unless they are deliberately included.

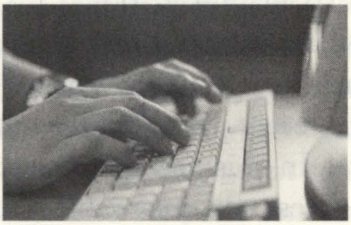
One of the technological solutions to the problem of the decline of global fisheries, for example, has been the creation of industrial fish farms, which are operating now on a massive scale. These industrial fisheries are inherently no different from industrial "factory farming" of livestock.

As Meadows, Randers and Meadows recount, such factory fish farms have promoted the "diffusion of food wastes and antibiotics into marine waters, the spread of viruses and the destruction of coastal wetlands...These harmful effects are not a random accident. They result from the working of the market because they are 'externalities' that simply do not affect prices or profits in any important market for fish."

This being so, the externalities must somehow be incorporated into the price mechanism. For instance, a U.S. cap-and-trade system placed on sulfur emissions by generating plants has greatly reduced emissions of sulfur dioxide into the atmosphere in a way that took advantage of markets' inherent ability to allocate resources in the most efficient way.

Adam Smith in *The Wealth of Nations* pointed out that the selfishness of individual market participants can be powerfully harnessed by free markets to render valuable services and products to society. Building on this insight perhaps, society might be wise to further harness the selfish power of markets by going to another level with markets and pricing various long-term outlooks and externalities into them.

In other words, if free markets are used without consideration of limits they simply become facilitators of greater overshoot and collapse. To be truly useful in a sustainable society, free markets must operate within a deliberate, society-wide context of such sustainability, a context that deliberately embeds into the powerful price mechanism the recognition of society's highest goals.



31. COMPUTER SCENARIOS I

As mentioned earlier, authors Donella Meadows, Jorgen Randers and Dennis Meadows conducted a series of experiments with a sophisticated computer model of the world called *World3*. They asked themselves what would happen using different initial assumptions. They would run the model with a given set of assumptions and then observe the forecasted future outcome.

These model runs, called *scenarios*, are not set-in-stone predictions. Rather, they are potential pictures of how the world might look over time as various assumptions and trends are factored into the model. In effect these different scenarios say, "If you alter *this* input in *this* way then *that* is likely to happen."

Out of the many thousands of scenarios that these researchers have run, the vast majority result in overshoot and collapse. Indeed, as they say, they have to make some

fairly heroic assumptions in order to have their World3 results come out sustainably. But we'll get to that. First, though, let's look at their six main scenarios:

Scenario 1. This is the reference point scenario. It simply assumes that things will go on, in various areas, roughly as they have in the recent past. And the outcome is overshoot and collapse. In this scenario it becomes more and more costly to access non-renewable resources and deal with pollution. As a result, industrial output and food peak in a few years and are in heavy decline by 2030. Population peaks at about that year also and begins a steady decline.

Scenario 2. Starting with this scenario, the modelers make a series of very optimistic assumptions. In this scenario they make the assumption that humanity's non-renewable resources, including its global fossil fuels, are somehow *doubled* overnight. Then they make the further assumption that technology greatly mitigates and delays the problem of increasing costs as resources become more inaccessible or difficult to extract.

What happens in this scenario is that population and economic production are able to continue growing exponentially, so much so that global pollution of soil, water and air peaks at a level some *five times* the level of Scenario 1. This eventually causes major disruptions in health and food supply. Industrial output and population both peak around 2040 and collapse thereafter.

Scenario 3. To counter the dire pollution effects of Scenario 2, the modelers assume that humankind is so sagacious that it embarks on a course of reducing its pollution at the fantastic rate of 4% a year for many decades (far in excess of anything currently even contemplated). Yet the model still overshoots and collapses. Why?

What happens is that so much industrial capital is drawn off into the pollution and agricultural sectors—to keep the supply of food rising in the face of massive soil erosion and to abate the intense pollution from an exponentially increasing economy—that the industrial base eventually begins to starve from lack of capital. It peaks, again around 2040, and begins a precipitous decline.

Scenario 4. Along with the generous assumptions of the first three scenarios, Scenario 4 adds another one: That global society is able to make tremendous technological progress on increasing food yields per acre, thus ameliorating one of humanity's greatest vulnerabilities as its population grows. Yet, as in Scenario 3, the model still overshoots and collapses. What causes it this time?

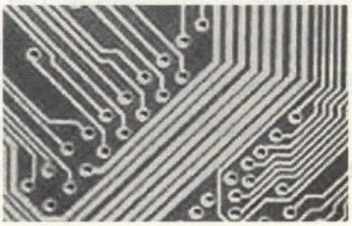
The agricultural intensity of Scenario 4—farming the land more and more intensively to produce higher yields—gradually erodes the soil. Soil exhaustion, coupled with reduced arable land from urban population pressure, carries the land downhill. M, R and M conclude: "The stressed agricultural sector pulls more and more capital and human resources from the economy, at

a time when the diminishing nonrenewable resource base is also demanding capital. A fairly total collapse occurs before 2100."

Scenarios 5 and 6 add other optimistic assumptions with the same outcome: overshoot and collapse. What emerges from these model runs is that humanity is not just up against one limit or two but a whole series of limits—stresses on the soil, the water, the climate, nonrenewable and renewable resources and so on.

A picture that comes to mind is one of those squishy toys where you press on it *here* and it bulges out over *there.* It's all connected. The basic story of these scenarios is this: *In the absence of addressing the central issues of economic and population growth,* attempts to solve the challenges of earth's ecological limits simply result in various forms of overshoot and collapse.

The bottom line of all this is that no amount of reliance on free markets and technology, by itself, can bring us to a sustainable future. Free markets and technology are powerful processes, and certainly a necessary part of any sustainable solution, but they are not enough. *In a context of continued emphasis on growth* they will lead, sooner or later, to an outcome of societal collapse.



32. COMPUTER SCENARIOS II

The most interesting scenario that M,R and M ran is the one that they call *Scenario 9*. This one, of course, is the sustainable one. So let's ask: What general assumptions did they have to make to achieve it?

1st assumption. Their first assumption was that the average number of children per couple *worldwide* came down relatively rapidly to the replacement level of 2.1, and remained there, allowing the population to peak and stabilize at about 8 billion people—but fortunately, no higher than that.

2nd assumption. Their second major assumption was that economic activity of all types—government, industrial, business and consumer—was skillfully guided, through worldwide cooperation and far-sighted leadership, to a stable state where, in general, economic activity was neither growing nor declining.

3rd assumption. The modelers third assumption is that renewable resources are brought to a sustainable level. This means that the whole interconnected biosphere—species, forests, soil, water, air and so on—is brought to a state of equilibrium. This meets economist Herman Daly's *first test of sustainability,* that renewable resources be used at a rate no higher than their rate of replacement.

4th assumption. Their fourth major assumption was to meet Herman Daly's *second test of sustainability*—that nonrenewable resources be used at a rate no higher than they are being replaced by renewable alternatives. This would mean, for instance, that fossil fuels were being used at a rate no higher than the rate at which alternative renewable sources—solar, wind, thermal, biomass, etc.—were coming onstream to replace them.

5th assumption. Their fifth assumption was to meet Herman Daly's *third test of sustainability*—that pollutants are emitted at a rate no higher than the rate at which the earth's sinks—the forests, soils, oceans, the atmosphere, etc.—can absorb and recycle those pollutants and render them harmless. Moreover, that in this recycling process the health of the sinks themselves is maintained and not further damaged.

Given those five assumptions, the model produces a society that is sustainable over time. Notice that technology alone won't do it, markets alone won't do it, pop-

ulation stabilization alone won't do it, stabilization of economic activity alone won't do it, and bringing the rate of use of renewable and nonrenewable resources to a sustainable level won't do it either. Only all of them together will do it. *Only by making all of these assumptions could the modelers bring the world to a sustainable state.*

Now, some notes:

1. Is the above a gross oversimplification of what Meadows, Randers and Meadows are expressing? Yes, in many ways it is. But I hope as well, without getting into too many details, that the above conveys something of the essence of their timely and important message.

2. A sustainable global population, economy and ecology does not in any way imply a static or stagnant society. Just as a river can maintain the same volume of water while constantly changing its contents, so would a sustainable society be continually molting as some things rise and others fall.

As M, R and M put it: "In an 'equilibrium society' like the one in Scenario 9, some people are being born while others are dying; new factories, roads, buildings and machines are being built while old ones are being decommissioned and recycled. While technologies are improving, the flow of material output per person would almost certainly be changing in form, diversifying in content, increasing in quality."

3. Though often accused of being unnecessarily pessimistic, in some ways the World3 scenarios are, if anything, optimistic. In M, R and M's words again: "It has no wars to kill people, destroy capital, waste land, or generate pollution. It has no ethnic strife, no strikes, no corruption, no floods, earthquakes, volcanic eruptions, nuclear accidents, AIDS epidemics or surprising environmental failures. Therefore it is, in many ways, wildly optimistic."

4. Perhaps most important of all, when they run the model with the same assumptions as in Scenario 9, *but delayed by 20 years,* the world enters collapse. In spite of all the formidable measures and successes assumed in Scenario 9, if those measures are implemented with too much delay the world cannot sustain itself and enters collapse anyway.

In other words, time is of the essence. A sustainable world is not a goal that can be delayed, minimized, or approached with half measures. To obtain a sustainable outcome, it is highly likely that humanity will need to exert itself to the utmost in terms of global cooperation, long-term thinking and sustained skillfulness, and do so with impressive rapidity.



33. THE AGRICULTURAL REVOLUTION

For millions of years human beings lived in close contact with nature. The predominant ethos of hunter-gatherer societies is exemplified by many of the original Native American tribes, who felt that the natural world was alive with spirit, and in some ways, spirit itself.

One has only to walk into a forest, or beside a seashore, or even just stand out under the starry sky to feel this. The beauty and majesty and mystery and spirit of nature come through strongly to anyone open to feeling it, and it is not difficult to feel a oneness, a sense of wholeness, a connectedness with all things.

The green theorist Paul Shepard has suggested that the first separation between humankind and nature may have occurred during the Agricultural Revolution some 11,000 years ago—since crops needed to be protected now from the encroachments of wild nature.

As humanity began domesticating and farming crops, for the first time the radical idea of staying in one place took hold. Now, for the first time, permanent homes could be contemplated and goods could be accumulated.

Researchers estimate that even a primitive farmer could produce 10 to 100 times more calories per acre than hunter-gatherers. From this surplus of food, and the idea of staying in one place, arose villages, buildings, cities, hierarchical organizations, commerce and so forth.

Furthermore, specialists could arise for the first time—carpenters, laborers, kings, soldiers, artists, priests, philosophers, and that truly pitiful class, the writers—the whole panoply of specialists. Out of this has come many of the glories of the human race.

But also, perhaps, farmers and the other inhabitants of the community felt a separation from nature for the first time. Now crops and orchards could be threatened by pests, floods, droughts and other natural disasters. And in early farming there was a constant struggle to keep wild plants from encroaching upon the crops. Thus farmland became something to protect from wild nature—a subtle dualism had crept in.

The rise of language also played a part. Now for the first time we were naming things, and in the very naming of the world we objectify it. Now there's a "tree" and a "wave" and a "dog" and so forth. Now there's a "me"

and a "you." Though language has vastly increased our power, it also has come with a price because our sense of duality has increased.

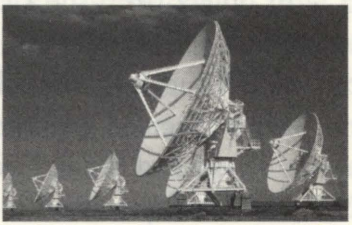
Another contributor to our sense of duality, interestingly enough, was that shining moment, the Golden Age of Greece. Humanity reached a temporary but brilliant apotheosis as dramatists, historians and, that glory of glories, democracy—first promoted by Cleisthenes of Athens in 508 BC—took center stage.

And yet our sense of separateness from the natural world also increased during this Golden Age, as we had the beginnings of philosophy and Plato's and others' idea of eternal forms. According to this viewpoint, which has been extremely influential in human history, the natural world—which is subject to change and decay—is merely a reflection of an ideal eternal world far off in the heavens somewhere. The natural world, then, is derivative and secondary.

The green theorist Stephan Harding describes it this way: "Plato thus inaugurated the notion of an eternal heaven hidden beyond the material world, an ideal realm where the true source of things really exists...this notion led to an increasingly dualistic way of thinking, according to which everything genuinely meaningful and wondrous about the world was assumed to exist elsewhere, in some otherworldly dimension."

This schism between the ideal, spiritual world and

the natural world was deepened and extended in the Western World by the Christian Church, and its outgrowth, the Protestant Reformation. Now the natural world was conceived of as a sinful, mean, fallen place which one tried to escape by going to the heavenly realm of God and spirit.



34. THE SCIENTIFIC REVOLUTION

The Scientific Revolution, starting roughly about 1600 AD, was one of the greatest advances in human history. For long centuries and eons, humanity's power to think had been held in the grip of superstition and received belief.

What is received belief? An example: Aristotle in the 4th century BC, based on thinking it over, decided that heavier objects would fall faster than lighter ones. This seemed the reasonable way for matter to behave: heavier objects fall faster than light ones. Trouble was, matter did not actually behave that way. *Yet this untested notion was believed for 2,000 years.* (I don't mean to knock the classical philosophers; in general they were powerful contributors.)

Galileo, among others, came up with the idea that to accurately learn about the natural world we must actu-

ally test our ideas against reality. What a concept! Thus Galileo proposed, and carried out, an experiment where he dropped a heavy and a light object from the Leaning Tower of Pisa in Italy to see what would happen.

Until Galileo, nobody had thought to actually test Aristotle's assertion. It was simply received wisdom. But Galileo found that the heavier object and the light object fell at the same speed. In fact, he was able to work out the mathematical formula involved, for the acceleration of objects under the influence of earth's gravity.

Which brings us to another point: Theorists of the Scientific Revolution such as the scientist Galileo, the philosopher John Locke, the author Francis Bacon and others, became convinced that the best way to decide if a notion was empirically verifiable was to use *quantities*—numbers—and the language of mathematics to describe it. If the process involved could be measured, it could possibly be verified. Conversely, without measurement there could be no true verification.

In keeping with this, Locke emphasized that the primary qualities of the natural world were what could be measured—size, shape, weight and so forth. Subjective, felt experiences of the natural world were regarded by Locke as "secondary qualities"—of lesser importance.

This deep revolution greatly accelerated humanity's understanding of the physical world. Superstitions and received knowledge were now subject to verification to

see if they were accurate. Many old beliefs fell by the wayside, including the belief that the earth did not move. Nicolaus Copernicus in 1643 disputed that notion and showed evidence that the earth was *heliocentric*—it moves around the sun. This and other new notions were nothing less than an earthquake in human understanding.

With this greater understanding, of course, also came increased power "over" the natural world. It was assumed now that humanity had the right, as well as the increasing ability, to exercise dominion over the physical universe. Bacon said explicitly that nature "takes orders from man and works under his authority."

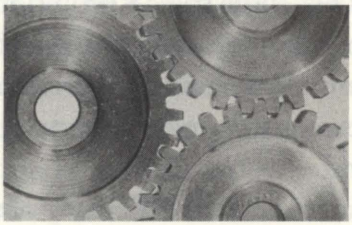
This dualism between humanity and the material world was made most explicit by Rene Descartes, who emphasized the decisive difference between *mind* and *matter.* In contrast with the soul of the human mind, he said, the entire natural world was merely a tremendous machine, dead and soulless.

These early stages of the Scientific Revolution reached a kind of apotheosis with the publication, in 1687, of Isaac Newton's *Principia.* Newton's deep equations showed that the motion of balls thrown in the air and the motion of the heavenly bodies were subject to the same underlying mathematical laws.

In Stephan Harding's words, this showed that "the world was indeed no more than a vast machine whose behavior could be precisely predicted and explained by

means of quantification, reductionism and systematic experimentation."

While this, along with other scientific advances, was a large leap in humankind's understanding of the material universe, it also reinforced the notion that the natural world was fundamentally mechanistic—and as such, to be studied, considered and acted upon with a certain degree of indifference.



35. THE INDUSTRIAL REVOLUTION

The Industrial Revolution could be said to have begun with the invention of James Watt's (improved) steam engine in 1769, though of course it had its precedents including the transition from wood to coal for energy, and not least, the Scientific Revolution itself, which led directly to an emphasis on technology and industrialization as practical applications of the new scientific knowledge.

The steam engine basically arose as a response to a problem in mining the new energy source: coal. Water would flood the coal mines and had to be continually pumped out by very inefficient methods. Savery and Newcomen worked out early models of steam engines, but it was the improvements made by Watt, especially a separate steam condensation chamber, that really galvanized the use of this new mechanical labor.

That's really the crux of the matter. Up to that time, of course, all labor was dependent on human and animal muscle power. The Industrial Revolution was essentially about replacing human and animal muscle power with mechanical muscles—hugely increasing the human race's ability to exercise its new-found "dominion" over the natural world.

Watt's new engine increased the efficiency of steam engines by a factor of *five times.* The first effect was a tremendous increase in the mining and production of coal, the new high-powered energy source. In 1825 the new steam engine was applied to the creation of a new more muscular form of transportation—the train. Trains and steamships now dotted the landscape and seascape, vastly increasing trade and commerce and, not least, the exchange of information.

In some sense it could be said that Gutenberg's invention of the printing press around 1450 AD (along with his Chinese forerunners) was the appearance of the first machine, using the radical idea of movable type to create its own revolution in the dissemination of information. But now, in the Industrial Revolution, industrial machines appeared which were *mechanically powered.*

Further, Watt's engine for the first time could drive rotary machinery, which allowed mechanical engines to power mills and factories, as well as modern machine tools such as lathes, which allowed the creation of even

more sophisticated and powerful machines and engines.

The existence and use of the steam engine led directly to the rise of the industrial *factory.* Now for the first time the production of goods and other machines could itself be mechanized. But conditions in the new factories were severe, with among other things the mechanization of human labor—now working to a machine timetable—as well as brutal hours and working conditions and the exploitation of child labor.

However, the factories paid better than the farms and so people flocked to the new factories for work, beginning a mass exodus of population from the farm to the city—a trend which continues even today with the world's increasing urbanization. The rise of the modern city occurred in parallel with the Industrial Revolution, and by the mid-1800s cities all over England and elsewhere were beginning to be dotted with the smokestacks of the new factories.

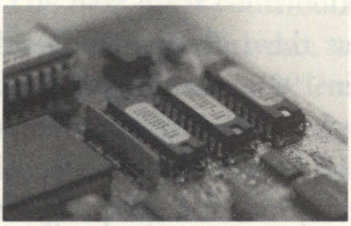
About 1850 or so, the second wave of the Industrial Revolution began with the first use of steel and the rise of the petroleum and chemical industries, and later, the invention of the internal combustion engine along with the widespread generation and use of electricity, and the rise of the automobile. It goes without saying that these developments and others brought about radical changes in human lifestyle and outlook.

In time, as well, the Industrial Revolution brought

about a great increase in the wealth and material well-being of much of humanity. However, the cost was high since an even further deepening of the schism between the mind and nature came into being. Now, with our new power, the natural world was to be *really* dominated, conquered, exploited and made to serve the new industrial economy.

In addition, as people increasingly moved to the cities they left behind their age-old rural lifestyle and along with it much of their remaining connection to the land. The new inhabitants of the crowded cities lived in very squalid conditions (immortalized by Dickens) and worked long hours in brutal factory conditions to the pace of cranking machines. And later, with the rise of the consumer economy, all things—the fruits of nature, labor, even one's time—became viewed as commodities.

Though much was gained, much was lost. In the process of this tremendous gain in humanity's wealth, energy and power, and in spite of boons such as electric lighting, antibiotics and, as time passed, improved living conditions for many, humankind also continued its headlong and increasing alienation from the natural world.



36. THE INFORMATION REVOLUTION

The successor to the Industrial Revolution has been the Information Revolution. I'm not referring here to Claude Shannon's information theory, though it was certainly seminal, but rather to the rise of computing machines, a development which has profoundly affected all aspects of contemporary society and lifestyle.

A part of the significance of this new revolution derives from this: Whereas the Industrial Revolution was about obtaining the assistance of the *physical* power of machines, the Information Revolution is about obtaining their *mental* assistance. In the former, humankind was increasing its muscular power. In this new revolution, humanity has been discovering how to create machines that amplify its mind power.

As earlier in this series, I'll be making some terrible generalizations below—terrible because they ignore the

important contributions of so many people—but I'll be doing so in the interests of simplicity, so that we can keep sight of the main journey.

We could posit that the Information Revolution began with Alan Turing in 1936, with the publication of *On Computable Numbers.* In it, Turing proposed something very cool: He said, and proved, that if the solution to any problem could be represented as an *algorithm*—like a recipe, a list of instructions—then a *general purpose computer* for solving any such problem was theoretically possible. (The real-life proof that he was right is the computer in front of you.)

He also proposed, for the first time, the use of the *binary system* for representing computations. The binary system uses only two digits, zero and one. The significance of that is that these two digits can be easily represented in all sorts of physical systems—for example, as on or off in an electrical current or as north or south in a magnet. This opened up tremendous opportunities for the calculation and storage of information that did not exist before.

The first actual use of the binary system in a programmable computing machine was by Konrad Zuse in 1941. It was a mechanical computer that relied on the use and arrangement of mechanical relays, but it was a proof of concept—it demonstrated that a general purpose computing machine was not just a theory but could

actually be constructed, though of course this first one was very primitive.

The next great contribution, perhaps, was by John von Neuman in 1945, who, among other things, proposed the idea of *conditional branching* in a program, that is, that the computer could come to a certain point in its instructions and then perhaps branch off to some other point in the program. This allowed for the existence of *subroutines* which could be called upon by the program at any time. Conditional branching and other von Newman advances greatly facilitated increased creativity in the programming of computing machines.

Then, in the mid-1940s, came the first electronic computers that used vacuum tubes instead of mechanical switches and thus calculated much faster. In 1947 came the invention of the transistor and then in 1958 the integrated circuit, all of which allowed for a great acceleration in the speed and thus the complexity of computation—an acceleration which has continued to this day.

In the following decades the developments came thick and fast: the first mini computers, then the first personal computers, then the creation of the internet in 1969, the creation of HTML and the World Wide Web in 1989 and so on.

Today humanity is exploring virtual reality which eventually, it seems to me, may rival physical reality itself. And we're attempting to create self-directing androids

with artificial intelligence, an endeavor which will indeed succeed but which may turn out to have an unexpected consequence—because our new creations will very likely supplant us humans eventually as the dominant species on planet earth.

What is the outcome to date of this latest shift in consciousness, the Information Revolution? Of course, it has resulted in a staggering rise in humanity's power in the mental and physical worlds—everything from the computers that handle trillions of banking transactions to the computers that analyze the paths of tiny particles in giant accelerators. We're now assisted by computers in everything from the creation of videos to the timing of valves in our auto engines. Yes, it's a brave new world.

On the other hand, along with all this newfound power, the Information Revolution, it could be argued, has deepened once again our general disassociation from the natural world. Humanity increasingly does its work and even takes its recreation while staring at patterns on computer screens.

We are operating at higher and higher levels of abstraction, so to speak, which is a double-edged sword. At the same time that it increases our power it also tends to increase our alienation, subtle and not-so-subtle, from the natural world.

We have only to look at the melting glaciers, the pollution of soil, water and air, the disappearing species

of plants and animals on land and sea—and many other things—to realize that humanity's arrogance towards the natural world has reached epic proportions.

We seem to have struck a Faustian bargain, where our giddy heights of power have been achieved at the expense of our natural perception that we humans are *participants* in the living natural world rather than the lords and masters of it.



37. GENERAL PRINCIPLES #1 & 2

Ten general principles for a sustainable planet

It is not too difficult to draw up a list of helpful actions in the effort to restore the biosphere: Compost organic material, recycle, use energy-efficient light bulbs, sequester CO2 from coal plants, buy hybrid or electric vehicles or a bicycle, cultivate renewable energy, design and use more efficient appliances and so on. All of these actions and many others are desirable and necessary.

But I agree with Meadows, Randers and Meadows: What we humans really need is a new revolution—the Sustainable Revolution. A revolution in how humankind looks at itself, a revolution in how humanity looks at nature and the earth and all of life.

Central to this revolution will be a *vision* of a sustainable world. Why a vision? Because everything begins

with a vision. It is the *vision* of a sustainable earth, a vision held by all humanity, a vision held by all of us together, that will create a sustainable planet.

Without such a vision, held by almost everyone, our actions risk being misdirected, counter-productive or ineffective. Because actions without vision are blind. It is the vision of a common humanity, working for all, serving all, that will above all bring about a steady-state society, that is, one that can continue to exist. The alternative is collapse, perhaps even collapse of the whole human experiment.

What might be the components of such a vision? No doubt it will be something that gradually comes into greater and greater focus, like focusing a camera lens. All good visions develop that way. However, perhaps the following notions about such a vision might be helpful:

1. Emphasis on long-term vision and planning

Looking down the road as best we can, collectively seeing a long-term vision and planning for it, will almost certainly be an essential component. Our actions towards the natural world—not to mention each other—have often been geared to the expedient and the short-term, to that which will get us "what we want" the quickest.

Instead, we as individuals, as consumers, laborers, executives, politicians, educators, scientists, artists and so

on—all of us—can deliberately, to whatever extent possible, shift our focus to the longer-term: What will be the effects of this action decades from now? What will be the effects of this action centuries from now?

Thinking ahead decades and even centuries may seem wildly unrealistic now, and will probably always be difficult, yet I believe powerful efforts at such vision and planning will become commonplace if we truly do evolve to become a sustainable society.

2. Looking to causes rather than symptoms

There are various high-tech schemes about to solve the challenge of global warming: One is to position giant mirrors between the earth and sun that would deflect a certain amount of sunlight away from the earth. Another scheme is to seed the oceans with iron to stimulate the biological pump.

A serious objection to such schemes is that they concentrate on the symptom—global warming, in this instance—instead of the cause—emitting greenhouse gases into the atmosphere. Perhaps giant mirrors in space *would* lower earth's temperature; however, the unintended consequences could be severe or even cataclysmic.

As noted, such schemes are not getting at *the cause* involved. To position giant mirrors in space or seed the oceans, for example, while continuing to emit increasing

amounts of greenhouse gases is like stepping on the brake and the accelerator at the same time—likely to lead to, at best, unpredictable outcomes.

This is not to be against technology. There is no going back, we are immersed in technology. But let's direct our technology to serve a deep connection to, and humility for, nature—by concentrating, for example, on the development and implemention of renewable energy rather than extracting every last drop of non-renewable fossil fuel from the earth.

And for example, before partially blocking the light from the sun let's investigate our addiction to the growth imperative and concentrate on getting our greenhouse gases to an ecologically sustainable level.

If we really do desire a sustainable planet, it seems probable that we'll need to approach our situation in a deeper and more fundamental way, that is, *by getting in touch with our deep embeddedness in nature and letting our solutions come out of that consciousness.*



38. GENERAL PRINCIPLES #3 & 4

3. Steady-state population and economic activity

This subject has been discussed earlier, but is mentioned again here since it would seem to be a crucial part of any sustainable vision. The reason it's so important is because nothing else will work without it.

We can use alternative fuels, use more efficient appliances, sequester CO2, endeavor to preserve forests and water and biodiversity and so on, but if we don't come to grips with our worship of growth at all costs then all else will be for naught.

And really, the vision isn't to stop things or hold things right at the limits of the earth's carrying capacity. Given that we can never know with certainty just where those limits are, it would be wise to envision living *under* the earth's limits rather than at them.

As M, R and M point out, there is an unavoidable trade-off between the limits of population and the limits of economic activity. The material level at which the average person on earth can be supported is very much affected by how many people there are, and vice versa. Further, as World3 suggested to us, the longer we delay the more difficult and constrained this trade-off will be.

It is even conceivable that a global society, finding itself in overshoot, could contemplate *negative* growth in certain areas, or even overall for a time, to attempt to get back under the earth's limits in a voluntary and steady way rather than through an involuntary collapse.

Thus an important part of the vision is to see population and economic activity holding in a steady state, in a way that is creative, heartful and equitable, in a way that serves all of life on planet earth.

4. Meeting the three sustainable conditions

Along with achieving equilibrium in population and economic activity, a worthy vision will almost certainly include Herman Daly's conditions for sustainable use of resources. To recap briefly:

—To be sustainable, the rate of use of *renewable resources* must be below the rate at which they are being regenerated;

—The rate of use of *non-renewable resources* must

be below the rate at which appropriate renewable substitutes are being found and brought onstream;

—The rate of *pollution emissions* must be below the rate at which the biosphere can sustainably detoxify or assimilate them.

These conditions, of course, apply at two levels: There is the separate level, where resources are considered individually in terms of meeting the conditions for sustainability. Resources such as water or fossil fuels or forests or CO2 assimilation in the atmosphere must individually meet the conditions for sustainability. Are we using our forests renewably? Our fresh water? Are we using our fossil fuels no faster than renewable energy sources are coming online to replace them? And so on.

Then there is the general, global level. Since all things in the biosphere are so connected, we also want to ask: Globally, are we implementing adequate renewable substitutes for non-renewable resource losses? Are we below the earth's carrying capacity in terms of overall assimilation of pollutants? And are we below the earth's limits for regenerating her renewable resources? One of the biggest challenges of the 21st century will likely be accurately responding to such questions.



39. GENERAL PRINCIPLE #5

5. Efficiency of each energy & resource use

Nature is so wise. In nature all processes work in closed loops. That is, the output of one process is always the input to some other process or processes. Animals and plants depend upon each other. The oceans and the clouds and the trees depend upon each other. Everything depends on everything else in nature's interlocking systems. For instance, countless organisms work to break down the end of life in various ways so that its components can be offered up into life again.

Nature has much to teach us. To create a sustainable planet we'll want to create closed loops in our industrial, business and consumer systems, so that each output becomes the input to some other process. On a sustainable planet, virtually all systems will form closed loops—

what theorists call "industrial ecology."

Recycling can form one corner in a potent triangle of envisioning closed loops in all our economic activities. When we recycle something we are building the beginning stages of a closed loop. Now "output" materials are being sent back into the system as "input." It's a very good start to becoming more efficient.

The second leg on the efficiency triangle is to look at the efficiency of different stages in a production process. For example, rather than trying to take the CO2 out of the end-stage smokestack of a generating plant, we might look at earlier, more efficient stages where the CO2 could be handled or reduced—and then of course, look at where that CO2 could become the input for another process.

Same for materials. As M, R and M point out, "A rule of thumb says that every ton of garbage at the consumer end of the stream has also required the production of *5 tons* of waste at the manufacturing stage and *20 tons* of waste at the site of initial extraction (mining, pumping, logging, farming)."

Conversely, any way in which we can reduce the amount of material used in a product not only reduces waste at the consumer phase, but also and much more so, at the manufacturing and extraction phases.

For the same size and horsepower, for example, a car of today is much lighter than the car of a few decades

ago. That's efficient. It not only reduces the material in the car itself, say for example the copper in it, but also greatly reduces the resource depletion and waste generated in mining, refining and shaping that copper.

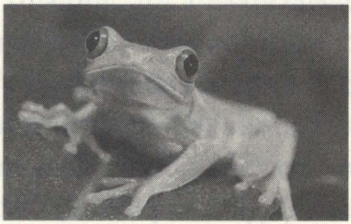
This is the famous "dematerialization" that theorists talk about. They see an economy in which the amount of materials (and energy) needed to create something is constantly being reduced through innovation. That sounds good to me—though as we've discussed, technology by itself cannot solve our human challenges and an overreliance on it in the absence of other measures almost certainly will invite disaster. As the mathematicians say, "necessary but not sufficient."

The third leg of the efficiency triangle is to increase the lifetimes of products and processes. If we double the usable lifetime of a product, for example, we have simultaneously halved the materials needed and the waste generated in making, distributing and consuming that product.

In the movement to become more efficient, every little bit will help. For instance, the Unity church that I attend at times has started using washable coffee cups for the after-service social instead of paper and plastic cups. A small thing, right? Yes—but it's exactly in the right direction, since the most-efficient paper or plastic cup is *the one that doesn't have to be made.* Similarly, the most ecologically-friendly coal generating plant is the one that

doesn't have to be built. And look at bicycle-friendly Copenhagen: The "greenest" auto is the one never built.

Multiplied billions of times, as we all pitch in and consciously work on our ecological and other challenges in various ways, even our smallest efforts towards long-term efficiency and closed loops in our industrial and consumer lifestyles will play their part in the overall movement of green action and consciousness that can move humanity and its various processes towards the natural sustainability of nature.



40. GENERAL PRINCIPLE #6

6. Letting prices "internalize the externalities"

We've discussed externalities elsewhere, but let's briefly review them: An *externality* is a term used by economists to denote some cost left out of the price of something. For example, the cost of the water consumed to grow a pound of food is usually so low that the water used is generally not part of our buying decision; it is an "externality."

The whole idea of "internalizing the externalities" is to bring those externalities into the buying decisions of businesses and consumers, so that those decisions are influenced. Internalizing the externalities is how we can take advantage of free markets within the context of meeting society's overall goals, such as reforestation or sustainability.

There are basically three mechanisms for using the power of markets to achieve overall societal goals: *labels, taxes* or *cap-and-trade systems.*

We've discussed *cap-and-trade systems* previously in this book. A good example is the carbon cap-and-trade system now developing in Europe, where an overall cap on emissions is set by the government and then companies trade carbon allotments (rights to pollute) back and forth in order to meet their emission limits in the most efficient way.

A second way is through *taxes.* An illustration is the *carbon tax,* also discussed earlier. A carbon tax incorporated into the price of a gallon of gasoline or a kilowatt of electricity, for instance, would affect everyday business and consumer decisions in a way that could contribute to society's overall goal of reducing CO2 emissions.

In my opinion, ecological taxes are the most powerful and efficient of the three ways of implementing sustainability goals, but of course their greatest downside is that taxes are politically difficult. In spite of the political difficulties, however, ecological taxes may be increasingly used down the road as humanity's ecological challenges become more grave, and thus more powerful solutions—yet ones which don't fall into the trap of totalitarianism—are sought.

The third way is through *labels.* A label does not affect the buyer or consumer as much as a tax, yet it

brings more awareness to a situation and can thus affect purchasing decisions in that way.

Imagine, for instance, wandering in a department store or online where every product has a *carbon label,* specifying how much carbon dioxide was emitted in the manufacture and distribution of that product and in the mining and refining of the materials within it. Imagine a *materials label* on each product everywhere, specifying the amount of scarce material resources used in its manufacture. Now imagine too a *water label,* specifying how much water was used in the manufacture of that product and its components.

A water label is likely to become increasingly used. We've discussed previously the global water situation: In a word, humanity is using up the fresh water of its rivers and aquifers at a rate that is depleting them and is unsustainable. As the 21st century progresses we may see water become even more of an issue than energy, though of course both of these issues—and their potential solutions—are intimately connected.

If everything had a water label, what would we discover? Actually, some astonishing things, as Fred Pearce notes. The first is that most fresh water is not used in homes or industry, but by far *for the growing of food.* The second is the astonishing amount of water actually used in growing a food—called its *virtual water*—an idea introduced by Tony Allan. Anyway, if virtual water labels

were on our foods here is one of the amazing facts we would discover:

–To produce 1 kilogram of wheat takes *over 1,000 liters of water.*

Think about that: To produce a single kg of wheat (about 2.2 pounds) takes over 1,000 liters of water. Here are other examples. To produce:

–1 kg of potatoes takes *540 liters* of water;

–1 kg of barley, *1,300 liters* of water;

–1 kg of eggs, *3,300 liters* of water;

–1 kg of cheese, *5,000 liters* of water;

–1 kg of milk, *6,200 liters* of water;

–1 kg of beef, *16,000 liters* of water.

That last item was not a misprint, by the way. It takes huge amounts of water to produce food from livestock. Notice that, in general, as we go from vegetables to dairy foods to animal foods we use up larger and larger amounts of fresh water. There are a few exceptions, but that is the general trend.

However, perhaps the most astonishing fact of all is how little virtual water, by comparison, fruits use. For example, to produce:

–1 apple, about *70 liters* of water;

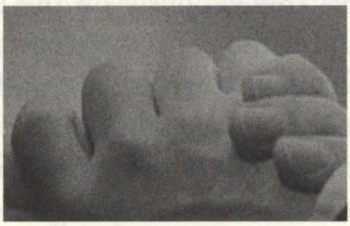
–1 liter of orange juice, about *22 liters* of water.

Notice that fruits take far less water than other types of foods. As our ecological challenges become more severe, it would not be surprising to see a substantial part

of humanity eventually becoming vegetarians or vegans —or even fruitarians. If humanity were not growing food for livestock it would save tremendously on the use of water (as well as soil). And if the earth were covered in orchards (like much of Tikopia) it would be possible to feed humanity using even less water and soil while most likely greatly increasing our overall health. A sustainable solution indeed.

Ultimately, all three methods—labels, taxes and cap-and-trades—will almost certainly need to be used. A kind of *ecological label* might come into use which sums up in some formula the total impact of this food or product on the earth's supplies of fresh water, energy, raw materials and pollution sinks.

And it would not be difficult, if or when necessary, to convert such ecological labels into a comprehensive ecological tax, or an equivalent cap-and-trade system, to provide even greater effectiveness as human society moves towards true sustainability.



41. GENERAL PRINCIPLE #7

7. Equitable distribution of economic resources

This principle is about poverty. It seems to me that we can't have a sustainable planet without dealing with the issue of an equitable and sustainable distribution of resources. I think that those two are linked: equitable and sustainable. To create a sustainable planet will very likely mean that, among other interconnected things, the issue of *equitability* has been addressed.

Why are equitability and sustainability interlinked? Mainly, because a sustainable planet cannot exist without having achieved stability of population. For example, this is one of the things the Tikopians had to achieve in order to enjoy long-term sustainability.

To achieve population stability, both long-term and globally, means that the human birthrate per family has

to come down to replacement rate, roughly two children per couple (actually, 2.1), where the number of children born results in a continual and steady replacement—but replacement only—of those now living.

There's a well-known phenomenon among economists: The poorer a society is, the higher the birth rate tends to be. This makes sense: The poor often have scarce access to resources, education and birth control. Often the one resource available is to have more children. More children means more help with the hard labor of making a living. As a consequence, the average birth rate in the Third World is almost twice the replacement rate —on average, about 4 children per couple.

The second part of this phenomenon is that, as a society becomes more prosperous its rate of birth tends to go steadily down towards the replacement rate of 2.1. This too makes sense: As a society becomes richer, its children tend to become more expensive (to raise) and tend to survive beyond childhood, so it becomes natural to have fewer of them. In consequence, virtually all First World countries now have birth rates that are at or below the replacement rate.

What this suggests is that humanity will probably not be able to achieve true population stability without also achieving some minimum living standard for most or all of its people. If virtually all of the human race has a certain minimum living standard, then the global birth

rate will likely be *naturally* at or near the replacement level. And as discussed earlier, achieving a stability of our human population is the absolute foundation stone of a sustainable planet, since without it little else can succeed long-term.

On the other hand, if the Third World were to achieve the current living standards of the First World, it's estimated that humanity's ecological impact would rise by about *twelve times.* As Jared Diamond says, there is no-one, even among ecological skeptics, who believes that the planet could sustain a human impact of twelve times its current level.

So how then do we deal with poverty?

Since the earth is already in overshoot, to hold the human impact at a sustainable level means that humanity will almost certainly need to find a way to greatly reduce the ecological impact of the developed world—probably involving a substantial reduction in living standards—while simultaneously raising the living standards of the developing world to some minimum level. To do both of these things while bringing the overall human ecological impact down to a sustainable level will be a formidable challenge indeed.

Poverty has been an endemic challenge for humanity since the dawn of civilization. Simply giving food to the poor doesn't eliminate poverty. As Thomas Malthus pointed out, human population tends to rise to the level

of the food supply, as we can see in a number of recent examples around the world. Simply increasing economic production, per se, doesn't do it either. The GDP (gross domestic product) of the world has increased *14 times* since 1930—and yet poverty remains undiminished and the gap between rich and poor has increased.

This being so, how do we deal with poverty in a sustainable world then? I'm not sure. However, it seems to me that there may be a clue:

It's a significant fact that virtually every nation that has experienced great poverty has also experienced great ecological devastation. Almost all have experienced great increases of population coupled with deforestation, loss of soil and then rampant desertification. In simplified form, this progression often seems to go like this:

1. Deforestation and increasing population;
2. Resultant loss of soil and soil nutrients;
3. Desertification; farm losses; water losses;
4. Conflict and war over scarce resources;
5. Political instability and endemic poverty.

It's an oversimplification, yes. However, we can see roughly this progression in areas ranging from Haiti to Bangladesh, from Rwanda to Darfur. Another example: One-third of China is now desert and that is the part where the people are by far the poorest.

Another: Ten thousand years ago the Middle East was an area of lush vegetation. Now it's a desert and beset by endemic violence. Just coincidence? Maybe not.

As Diamond points out, if we make a list of the countries suffering the greatest ecological devastation and a parallel list of the countries suffering the greatest tension/conflict/poverty/political instability, the two lists tend to be remarkably similar.

Meanwhile, if we make a list of those countries that have the highest percentage of forestation and a list of the countries enjoying the highest prosperity, the two lists also tend to be very similar—Japan, Germany, the Netherlands and so on. Just coincidence? Maybe not.

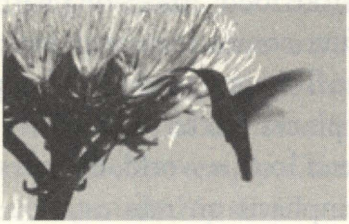
So one notion might be to put a focus on #1 above, where the whole process begins, and reverse it. Food and medicine, NGO investments, education, microloans and so on will all be important, but they almost certainly cannot bring about long-term success unless *population stability* and *ecological sustainability* (especially reforestation) are given a very high priority.

Reforested land automatically begins to build up the soil, and it attracts rain through the hydrological cycle. So the whole process can begin to spiral upwards instead of downwards. Is this a vision on par with singing Kumbaya around the campfire and hoping for the best? Perhaps so. And yet, and yet—perhaps a virtuous circle could begin:

Reforestation—especially if the trees bear fruit and shelter crops, as in Tikopia—tends to foster fertile soil, abundant water and therefore food. And along with that, coincidentally or not, often comes increased peace and well-being. It happened in Tokugawa Japan. It happened on Tikopia. Why not on planet earth?

Nothing is guaranteed in this world, of course, but a sustained and global emphasis on reforestation—and ecological rebuilding in general—might be a beginning in raising the living standard of the poor to a sustainable level—a point where the birth rate worldwide *naturally* settles down to replacement level, thus satisfying the first condition of a sustainable planet.

Ultimately, a sustainable world with an adequate though not excessive lifestyle for all of its people will almost certainly require a *vision* of that outcome held universally by virtually all of humanity. A compelling and humane vision would greatly foster fruitful and humane action which, in turn, would greatly foster enlightened outcomes. Even though there might be great difficulties, a steady and global envisioning of such a world would greatly increase the likelihood of its emergence.



42. GENERAL PRINCIPLE #8

8. Knowledge that peace is the way to peace

It's hard to imagine a sustainable planet that isn't also a peaceful one. Of necessity, a sustainable society would make intelligent use of its limited resources—and military use of resources is not intelligent. Whenever bullets, bombs, rockets and so on are used they not only tend to kill and wound people, but they also waste the capital, labor and resources that went into them.

Often, wars and conflicts are not only the result of a loss of resources, but they then accelerate that loss. In Mayan civilization, the incessant wars and conflicts over scarce resources certainly were a major part of its collapse. We can see the same phenomenon in the conflicts that took place on Easter Island during its collapse. We can see it in Rwanda, the Sudan, pre-Tokugawa Japan

and many other places. An earth in conflict is one that is prodigiously wasting resources—human, ecological and material—and thus almost certainly not sustainable.

But how to reach a peaceful world?

For one thing, it seems to me that peacefulness not only greatly assists sustainability, but that the reverse is true as well: sustainability greatly assists peacefulness. The two tend to work together, both on the upside and the downside. War, conflict and collapse can form a vicious circle downwards. Conversely, a worldwide effort towards sustainability can form a virtuous circle upwards: a human society not only of increasing sustainability, but also of increasing peacefulness.

It seems obvious that our beautiful world cannot become sustainable without massive participation from virtually all of humanity. If/when this comes about, this increasing participation in a common goal will tend to unite us over time, much like Tikopia and Tokugawa Japan. Conversely, if we allow conflicts of various kinds to dominate our agenda we will most likely share the fate of the Mayans and the Easter Islanders.

Consequently, perhaps the first and most important thing in this area is to *envision* a peaceable, sustainable world, one in which all of humanity is focused on achieving and maintaining sustainability—a *vision* of a green, forested, peaceable, equitable world. Everything begins with a vision, and such a vision would go a long

way towards fostering cooperative, peaceful and sustainable action.

The second thing to be said about peace comes from something that the luminous Byron Katie has said. Here it is:

Defense is the first act of war.

That is so utterly profound. Katie even gives an example of what she used to reply if someone said, for instance, that she didn't listen. She would bristle and say, "Of course I listen! How dare you say that! Who do you think you are? I listen!" Sound familiar?

That's resonant. I can recall countless times when I've said pretty much those exact words to someone. Defending and justifying, D & J. How many times in my life have I defended and justified myself? Hmm, how many stars are there in the sky?

My defensive and justifying words would often *begin* a war with someone that didn't need to be begun. Instead of bristling, I could have simply listened to what they had to say and enlightened myself.

It's a fact: Our worst "enemies" will sometimes tell us things that our best friends won't. We can learn a lot from criticism if we're willing to listen without reacting from fear. As Katie points out, anything that anyone calls us we can find somewhere. If someone calls me a liar, can

I find it in myself? Yes. I can either find it currently—in which case I've learned something—or I can find it at some other time in my life. Either way, in that moment my critic and I have joined; I'm not making war on my critic by trying to defend and justify.

Well, what about the larger arenas then? Does this mean that the Allies should not have defended against Hitler in World War II? No, it doesn't. But for every war that is justifiably defensive against a Hitler or an Imperial Japan there are probably ten unjustifiable ones. When listening isn't present, a war can begin that need not be. Look at World War I, or a hundred other wars. Look at the U.S. Revolutionary War: Britain chronically didn't listen to its colonists and a war was the result.

The statement "Defense is the first act of war" is really about listening, really taking in what the "other" is saying, really paying attention without reactivity.

An example. The U.S. is planning to put a radar station into Poland and a dozen or so "defensive" missiles into Romania—right on Russia's border—supposedly to defend against Iran. Now Russia is no saint on the world stage, God knows, but in this case it may have a point. It sees this as an extremely provocative act and is loudly saying so. But we're not listening. We're planning to put the missiles in anyway as a "defensive" measure.

What's interesting about this is that there is no conceivable tactical advantage that we could gain from

this act that would not be completely overridden by our strategic loss. Our aggressive actions are fostering a new arms race with Russia, helping to create it as an enemy. If we listened here, we might learn something.

The U.S. is not doing a lot of listening these days. It's not alone in that of course. Many other countries are not listening either and blindly acting in their own self-interest. But I know the U.S. best, so I'll focus there.

For example, we're not listening to our critics in the Muslim world. They see us as imperial occupiers in Iraq —invading a country that did not attack us—as well as facilitators of the suffering of the Palestinians by our one-sided support of Israel. They say that the U.S. has lost the moral high ground—which it used to occupy—through Abu Graib, Guantanamo Bay, rejection of the Geneva Conventions and so on. Such things are being said all over the Muslim world, indeed the general world, but we're not listening.

I must say, it seems to me that everything we're doing in the Middle East is just helping to create more terrorists. Terrorists grow out of the soil of deep anger in a population. The more ham-fisted military "solutions" we chase after, the angrier people across the Muslim world become and the more we're creating terrorists—supposedly the very thing we're fighting.

Perhaps we could learn something from our critics in the Middle East and elsewhere—we could enlighten

ourselves and our policies, leaving behind our pugilistic stances for something less fearful.

Why should the U.S. listen when other countries aren't doing much of it either? Because the U.S. has often set a good example in the world. We could do so here.

This planet has many challenges. There is a lot of work ahead to create a sustainable planet, so let's get started together. Over time, focused on a common goal, friendship could replace our polarizations—and results could occur which we might not think possible now.

To put it in geopolitical terms, we could be thinking strategically about the long-term aspirations of the world instead of confrontationally about our short-term tactical interests. For example, we could be leading—*by example*—a worldwide journey in creating a sustainable humanity and a sustainable planet. This is a goal and process potentially so inspiring and so illuminating that conflicts among nations could actually begin fading from sheer lack of interest.

Am I guilty of being a Pollyanna again? Perhaps so. And yet—I do love the notion of a shared human vision, whether it be this one or some other—a shared vision so compelling, so uniting, that old conflicts tend to melt just in the warmth of its light.



43. GENERAL PRINCIPLE #9

9. Sustainable world does not mean stagnant

Everything is a projection. Everything we see, the whole world, is a projection. I don't mean that it isn't there. Reality is there. But as soon as the mind begins labeling things—this is a "tree," that is a "person," this is a "sky"—we begin breaking reality up into parts, parts which don't actually exist as separate things since there are no separate things. There's only one existence, which includes everything. There's only the One.

As Byron Katie so brilliantly points out, we then take our labeling and projections to another level, creating a fantasy world of belief that goes like this: "They should not have done what they did." "My father should have loved me." "I'll be happy as soon as I get that." "War, killing and pollution shouldn't exist."

And one thing follows upon another. If reality as I perceive it is a projection of my stories about it, *then a sustainable world must begin with me.* If I want to stop war in the world, can I first stop the war in my own mind? — my war on reality-as-it-is? If I want to end pollution out in the world, can I first end the pollution in my own mind?—the pollution that results from believing my long list of *shoulds* about reality?

The mind tends to believe that a number of things should be different than they are: "Cheryl should love me." "John should appreciate me." "That should not have happened." "Conflict shouldn't exist." "Reality should be kinder." "Jimmy should get a clue."

But if I want conflict to end, can I first stop the conflict in myself?—the conflict I'm waging with reality, the conflict that says that I'm wiser than reality is and that I'm going to tell *it* how *it* should be different? I do recommend Katie's website for this *(thework.com).*

Maybe, by ending our war with reality and coming to love it just as it is, we'll end up being *more* nurturing, not less, and *more* effective, not less, in the challenging process of creating a sustainable world. We love the seed exactly as it is, see its perfection, and yet there's also a place for watering that perfect seed as it unfolds into its next perfection. We love the world exactly as it is, see its perfection, and yet there's also a place for nurturing it as best we can.

As inside, so outside. If we want to create a sustainable world outside, we first must create a sustainable world inside—one not driven by fear, resentment or disillusionment about the state of the world or each other or ourselves, but an inside world filled with the delight of knowing that reality is beautiful and that it's a joy to nurture it in any way we can.

This is the clear, open mind, not stressing out on trying to "fix" the world or "save" it, but one that works on creating a sustainable world in the same way that a flower sends out its perfume—because it's a joy to do so, because that is simply what it does.

A sustainable world, to work at all, cannot be a stagnant world. It can't be a rigid, inflexible world, one closed to new ideas or innovative ways of doing things. On the contrary, to be effective our minds must be as clear, open and flexible as possible. The challenge of a truly sustainable world is great enough that it will require the clearest, most joyful, most creative efforts that each of us can make. It will need clear minds.

Yet this emphasis on openness and flexibility will need to be grounded in a great humility, respect and love towards the natural world, a sense that we are embedded *in* it rather than dominant over it. Otherwise our efforts, even if well-intentioned, will most likely be misguided.

As mentioned, a sustainable world cannot be static and uniform. That is the common element of all totali-

tarian, top-down societies—a grey sameness of idea and belief that rejects creative and innovative solutions. A totalitarian world thus cannot be a sustainable world. A rigid world may appear to be stable for a period of time but it will not be truly sustainable.

So a sustainable world will almost certainly be a democratic, open world, even if it has a one-world government, as seems likely sooner or later. Certainly there will be rules, standards, boundaries, some of which will be very unfamiliar. But such rules, standards and boundaries can, if well-designed, increase freedom rather than constrain it.

A red light forces us to stop, yes, but it also allows for a practical flow of traffic. Similarly, carbon, water, energy or ecological taxes would be restrictive in one sense but freeing in another—they could allow us to live and work in a more sustainable world while imposing the least amount of restraint upon individual choices. In a similar way too, well-thought-out rules and standards concerning sustainability could help to increase, rather than decrease, humanity's overall freedom, well-being, diversity and creative energies.

A sustainable society would be very interested in *qualitative development* rather than quantitative development. And it would most likely be very flexible, having positive growth going on in some dimensions while negative growth is going on in others—a creative flux of ris-

ing and falling in different areas—a creative mix in which the long-term costs and benefits in each area will have been carefully considered.

As Meadows, Randers and Meadows say, in a sustainable world there would still be "challenges, problems to solve, ways for people to prove themselves, serve each other, test their abilities, and live good lives—perhaps more satisfying lives than any possible today."

A sustainable world will require the utmost in our ability to adapt and contribute in new ways—socially, economically, politically, artistically, philosophically and spiritually.

As John Stuart Mill said presciently in 1848, "It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture and moral and social progress; as much room for improving the Art of Living, and much more likelihood of its being improved."



44. GENERAL PRINCIPLE #10

10. Perceiving oneness of humanity & nature

In creating a sustainable world, perhaps the most important thing of all is to perceive that our divisions are illusory, that we are one. Who is this "we"? Everything, everybody, with nobody and nothing left out. In reality, we are one thing, one essence, one spirit.

The rational mind, which is always doing the best it can, is continually seeking an identification somewhere. After the primary identification—"I am a separate, personal being"—comes the secondary identifications: I am a woman or a man, I am single or married, I have *this* number of children, I belong to *that* tribe, I believe in *this* religion, I am a citizen of *that* country and so on. Our sacred identifications.

But ultimately, we are not black, brown, white or

yellow, woman or man, Christian or Muslim, Western or Eastern or any other distinction. Yes, we are those things, but we're also something deeper: We are all human beings together.

In my opinion, the planet will start becoming truly sustainable when human beings perceive themselves first and foremost not as belonging to this nation or that tribe or this race or that belief but as belonging to humanity. First, foremost, identifying ourselves as human beings—brothers and sisters to all other human beings.

When we see ourselves first as human beings and second as this group or that one, this belief or that one, this nationality or that one, then, in my opinion, we're on the road to a sustainable earth. On a sustainable planet, before attaching to all such labels or beliefs we would first see ourselves as members of a common humanity. We would see ourselves and experience ourselves first as an integrated living heart—the living human heart of our precious planet earth.

When we are inclusive enough to embrace all of humanity within our identification, we also begin to perceive that our identification can be widened even further, to include the mysteries and splendors of nature. It's not so much that we join nature as that we *rejoin* her, as in the days before the various revolutions, only now from a wiser, more experienced place.

Have you ever lain on your back in a woods some-

where and looked up at the blue sky and listened to the wind rustling in the trees and caught sight of birds flying in formation and just sensed deeply that it's all one living organism?

Quite apart from all the scientific demonstrations of the truth of Gaia—the earth as a living organism—it can be sensed, felt, understood. Just listen to the waves and seagulls on the seashore or look deeply at a flower or a blade of grass. This earth, this Gaia, this global biosphere can be sensed as an integrated living intelligence. And its intelligence is much deeper than ours, for it has the wisdom of being more natural.

It's amazing to study the integrated living cycles of the earth, the way everything contributes to everything else, the way that rhythms of all kinds feed into each other, the ineffable living network that maintains this planet—that is, itself—as a living, breathing organism. Ultimately, though, it is not about science teaching us: We just know. If we're open to it, we just know. The heart knows that we and nature are one thing.

Of course it's an illusion that we could exist separately from nature. If we're to survive, nature cannot exist as something to be dominated or exploited—even to think in those terms is to separate ourselves—but rather, as a partner with us, or even more accurately, as one unified energy that incorporates us. When our mind is clear and open we come into our birthright, which is to per-

ceive ourselves as an organic part of the living intelligence that is nature.

We cannot live without nature, that is how deeply embedded in her we are. Nature is our teacher: If we spend some time in nature, she teaches us about silence and majesty and transcendent beauty. She teaches us about connectedness. She teaches us about everything happening in its own rhythm and coordinating naturally in a self-organized symphony.

As Stephan Harding says so eloquently, "We need to sense that our every step is taken not *on*, but *in* the Earth; that we walk, talk and live our whole lives inside a great planetary being that is continuously nourishing us physically with her miraculous mantle of green and her luscious swirling atmosphere, a being that soothes our psyches with her subtle language of wind and rain, with the swoop of wild birds and with the majesty of her mountains."

And the broadening of our boundaries need not stop there. It can widen to include all of existence, all of reality, everything that is. To truly create a sustainable planet we'll need a great love affair—a great falling in love with our humanity, with the natural world, and ultimately, with all of reality just as it is.

In a sustainable world, each of us would know that we are one, that we're not separate—not from the natural world, not from each other, not from reality. Or to put

the same thing in different words, not from the infinite living intelligence that infuses all things and is who we truly are.

The earth is already an exquisite garden, and someday it will be even more exquisite—a garden where we live in symbiosis with nature and each other and all of life, and where our true love affair is with existence just-as-it-is, greeting us in every face and every sunset and every situation as our very own self, our own heart.

Joseph Campbell said this about it: "Where we had thought to travel outward, we shall come to the center of our own existence; where we had thought to be alone, we shall be with all the world."

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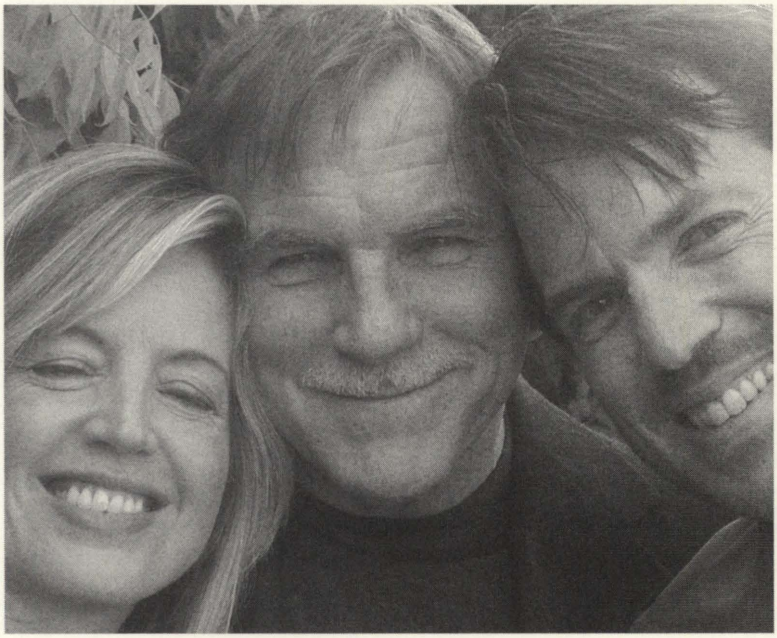
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js

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Photo, 2007: Jim with friends Lorraine and Richard Platt



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